A Summary of Current Program and
Preliminary Report of Progress

OILSEEDS AND PEANUT RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 1, 1965

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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology Research
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil and Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer and Food Economics
4 - Market Quality
4 - Transportation and Facilities
7 - Animal Husbandry
7 - Animal Disease and Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

1, 5 - Economic Development
4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Economic and Statistical Analysis
5 - Foreign Development and Trade
5 - Foreign Regional Analysis
5 - Natural Resource Economics

6 - Forest Service - Research (FS)

4, 5 - Farmer Cooperative Service (FCS)

4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the USDA program and progress for the following commodities and subjects:

6 - Forestry (other than Forest Service)
7 - Beef Cattle, Part I-a
7 - Dairy, Part I-b
7 - Poultry, Part I-c
7 - Sheep and Wool, Part I-d
7 - Swine, Part I-e
7 - Animal-Poultry and Products, Part II
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Horticultural Crops
11 - Oilseed and Peanut
11 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

INTRODUCTION

This report deals with research directly related to the production, processing, distribution, and consumption of oilseeds and peanuts, and oilseed and peanut products. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only oilseed and peanut problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organization unit reports of the several divisions.

The report is presented under three main headings: Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. There is also a breaddown by problem areas as shown in the table of contents. For each area there is a statement of (1) the Problem, (2) USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) a summary of Progress during the past year on USDA and Cooperative Programs, and (4) a list of Publications resulting from USDA and Cooperative Programs.

Oilseed and peanut research is supported by (1) Federal funds appropriated to the research agencies of the U.S. Department of Agriculture, (2) Federal and State funds appropriated to the State Agricultural Experiment Stations, and (3) private funds allotted, largely by oilseed and peanut industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service dealing with oilseeds and peanuts comprises investigations on breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering Divisions. The work involves 70 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to improved methods and equipment for mill processing of oilseeds and peanuts; development of new and improved food, feed, industrial uses of oilseed and peanut products; and nutrient values of oilseeds and peanuts. It is carried out by the Eastern, Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics Research Division; and Human Nutrition Research Division. The work in these divisions involves 115 professional man-years of scientific effort.

Marketing and Economic Research is done in three services. Marketing research in the Agricultural Research Service dealing with oilseeds and peanuts is concerned primarily with the physical and biological aspects

of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. It is carried out by the Market Quality, and Transportation and Facilities Research Divisions. The oilseed and peanut research in these divisions involves 6 professional man-years of scientific effort. Economic research conducted in the Economic Research Service deals with marketing costs, margins, and efficiency; market potentials; market structure, practices, and competition; outlook and disuation; and supply, demand, and price. Research in cooperative marketing is conducted by the Farmers Cooperative Service. The oilseed and peanut research in these services involves 9 professional man-years of scientific effort.

Interrelationships among Department, State, and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry affected participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects, oilseed and peanut research is in progress in about half of the 53 State Agricultural Experiment Stations. The type of work to which the largest amount of effort is devoted includes breeding and genetics, culture, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization, and economics. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Industry's participation in oilseed and peanut research is carried out primarily by manufacturers of farm machinery and equipment, processors of intermediate products, such as unrefined vegetable oil, and by manufacturers of consumer products, such as shortening, margarine, and peanut butter.

Basic research done by the Department and States is utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success.

New Oilseeds of High Industrial Use Potential. Crambe abyssinica, an oilseed source of erucic acid, will become a commercialized new crop in 1965. Seed obtained from 125 acres (USDA contracted) will be used for experimental plantings and for extraction, processing, and feeding studies. Crambe is widely adapted to the wheat-growing areas of the Northwest and upper Midwest, and regular farm equipment can be used for planting and harvesting. Erucic acid, the major constitutent of the oil, has utility in plasticizers, steelmaking processes, rubber, lubricants, and other industrial products.

Seed of a spurge (Euphorbia lagascae) from Spain contains 42% oil. This oil contains approximately 60% of an epoxy fatty acid which can find large markets in the manufacture of plastics and synthetic rubbers. The plant is an annual herb and a good seed producer. It should be adaptable to dry-land wheat areas of the western United States. About 45 pounds of seed were procured through the PL 480 project in Spain. This will permit Utilization Research to process enough oil for evaluation by industrial firms and will provide planting stock for replicated trials at a number of locations.

Control Measures for Soybean Cyst Nematode. The serious threat of the soybean cyst nematode to soybean production in North Carolina, the Delta, and elsewhere has been eliminated or reduced to minor significance. Development of the soybean variety, Pickett, which is of good agronomic quality and resistant to the most common nematode strain, was completed; and the variety has been approved for release. This variety will enable farmers in most affected areas to obtain satisfactory soybean production. It also has been established that control of the nematode can be obtained through crop rotation. The nematode population declines rapidly when nonhost crops are grown, so that even cyst nematode-susceptible varieties can be grown if they occur in the rotation only one year in four or five.

Superior cooking oil for world market. ARS scientists have developed new laboratory methods having promise for producing a flavor-stable soybean cooking oil and at the same time preserving its high nutritional value. Of further importance is achievement of the improved stability needed to withstand storage and transportation for foreign marketing. These methods are based on the discovery of new catalysts that show increased selectivity in promoting hydrogenation of linolenate, the unstable component of soybean oil. With the aid of an analog computer, it has been demonstrated that linolenate content can be reduced to adequately low levels without the need for winterization to remove excessively hardened oil. Studies are in progress on adaptation of these new methods for use by industry. Success should expedite the role of soybeans in supplying a large share of the annual world deficit of 4 billion pounds of food fats and oils.

Improving stability of linseed oil emulsion paints. ARS scientists have made an important contribution to expanding use of linseed emulsion paints by discovering a novel way to stabilize them. Linseed oil paints should contain zinc oxide to prevent growth of mildew on the paint film. In water-based paint systems, however, zinc oxide and titanium oxide, a white pigment used in most exterior paints, develop opposite electrical charges. The pigment particles attract each other and gradually clump together. This greatly shortens the storage life of the paint. Our scientists found that addition of a commercially available phosphate chemical overcame this problem and gave the paints the needed increase in storage life. This research also makes it possible to predict the occurrence of interactions between particles of other paint pigments that might be used, so that undesirable combinations can be avoided. Based on this and other pioneering ARS research, industrial production of linseed emulsion paints is making rapid gains. Three major producers are now marketing linseed emulsions for use in formulating paint. One of these alone is supplying emulsions to some 150 paint manufacturers. One of the nation's largest retailers is among those distributing linseed emulsion paints. The potential annual market exceeds 140 million pounds of linseed oil.

Crambe oil for the steel industry. Oil from crambe, a new crop being developed by the Department, has been evaluated in cooperation with industry as a mold lubricant for the continuous casting of steel. The results showed that crambe oil is superior to any other material for this purpose. In continuous casting, molten steel is poured through an oscillating mold. Proper lubrication of the mold is essential to ensure continuous emergence of a high-quality ingot. Continuous casting is a relatively new but rapidly growing process. Six years ago there were less than 20 installations throughout the world. Today there are over 100. The potential market for crambe oil in this process is 7 to 8 million pounds annually. Substantially increased plantings of crambe are planned this year to provide oil for this outlet and to encourage development of still further end uses.

Broadened Usage of Castor Oil is Expected as a Result of Methods for the Production of Low-Cost, Non-Burning, Rigid Polyurethane Foams. The construction industry is a potential yearly outlet for as much as one billion pounds of plastics for insulation and vapor barriers. Polyurethane foams with their unique property of on-site fabrication should realize a large share of this market as they become accepted by the building industry. A reactive liquid mixture can be poured into voids (e.g., roof, floor, or wall members); it foams up, filling the void, and provides rigidity and strength, as well as a heat, sound, and vapor barrier. Such foams are now mainly based on petrochemicals, but Department research has demonstrated that modified castor oil can be used to make polyurethane foams. These foams can be made flame-resistant with no loss in other properties by incorporation of reactive flame-resistant chemicals. The least flammable castor oil based foams are those prepared in one-step ("one-shot") systems from brominated

castor oil. These completely non-burning foams are significantly less expensive than similar fire-resistant foams based on petrochemicals. Based on the results of this Department research, several large fatty acid processors have initiated development programs in this field. Large increases in castor oil could result, requiring up to 200,000 new acres of castor.

New Fire-Retardant Paints Based on Tung Oil Offer Improved Market Potential and Protection for the Consumer. Major progress has been made by Department scientists in the development of water-resistant, intumescing, fire-retardant coatings based on tung oil and its derivatives, research conducted with the cooperation and support of the U. S. Army Engineer Research and Development Laboratories and the Pan American Tung Research and Development League. Although fire-retardant paints are available commercially, they are unsuitable for many domestic, industrial, and military uses, since they lack some requisite conventional properties, such as water resistance, and thus cannot be applied to exteriors. In the Department research, vehicles containing tung oil or chemically modified tung oil have been synthesized and formulated into fire-retardant paints. Some of these experimental coatings are highly resistant to water and to weather and have superior color and color retention, good drying and bonding characteristics, and other excellent conventional properties. They perform well in the standard Underwriters' Laboratories' 25-foot tunnel furnace. The tremendous industrial interest in the formulations indicates that commercialization would help consume large volumes of domestic vegetable oils--not only tung, which is an essential component, but also linseed oil, dehydrated castor oil, and others. However, the research has even more important implications, since effective fire-retardant coatings should greatly reduce losses due to fires: over 11,000 lives and over one and one-half billion dollars' worth of property annually in the United States alone.

I. FARM RESEARCH

SOYBEAN CULTURE, BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Soybean research problems are increasingly directed toward obtaining higher average yields. Soybean yields have not increased in recent years as rapidly as the needs for soybeans in the economy. Available land for further acreage increases is limited. Since the adaptability of soybean varieties is critically affected by the relative length of days and nights and by soil, climate, and disease conditions, it is necessary to produce varieties adaptable to many maturity zones.

Much of the increased yield in nonlegumes in recent years can be attributed to nitrogen fertilization. The soybean, as a legume, has an endogenous source of nitrogen in the symbiotic nodule system. However, more detailed and precise information about bacteria-nitrogen-soybean interactions is one of the most pressing needs in the research program.

Soybeans are important commercially because of their high content of oil and protein. Historically, the levels of these two important constituents have been negatively correlated, and protein negatively correlated with seed yield. The dilution of research effort in combining breeding programs to improve yield, oil, and protein reduces progress toward any one objective. Soybean diseases in recent years have increased in serious proportion so that certain diseases may approach catastrophic levels for some farmers. Genetic resistance has proved an effective method of dealing with certain diseases, but the search for resistance requires screening many thousands of genotypes. Once resistance has been found, incorporation into good agronomic types may be simple or complex depending on genetic linkages and the ease with which resistance can be identified. Adequate resistance has not been found for some of the most important diseases.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving breeders, geneticists, plant pathologists, physiologists, and chemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Research is conducted at Beltsville, Maryland, and in cooperation with Agricultural Experiment Stations of Florida, Illinois, Indiana, Iowa, Maryland, Mississippi, Missouri, and North Carolina. In addition the evaluation of experimental selections is conducted in formal cooperation with the Experiment Stations of Alabama, Arkansas, Georgia, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Nebraska, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, and other soybean producing States.

The Federal scientific effort devoted to research in this area totals 20.0 professional man-years. Of this number, 6.0 is devoted to breeding and genetics; 5.8 to diseases; 2.2 to cultural and harvesting practices; 3.0 to quality and variety evaluation; and 3.0 to physiology.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research in plant breeding and genetics, plant pathology, and agronomy. In many of the States, the research is conducted cooperatively with the Department. This research is continuing to provide useful information for the improvement of soybeans.

Soybean varieties have rather specific environmental requirements; hence many States are engaged in date of planting, rate of planting, and row spacing studies. Other cultural studies concern rotations, seedbed preparation, late seeding following small grain harvest, environmental interactions with diseases, and weed control.

Major breeding efforts are concentrated at a relatively few States but many States are testing the selections coming from these programs for local adaptation. The objectives of the breeding programs are improved resistance to disease and cyst nematodes, high oil content, yield, and seed quality. A few States are interested in soybeans for use as forage. Genetic studies concern the cytology of soybeans and related species, a search for various sterility-and cross-pollination-controlling factors, and factors contributing to yield. Biometrical studies are underway to evaluate selection methods, determine types of gene action, genetic correlation, and changes resulting from various methods of selection.

Illinois is evaluating soybean varieties and soybean products for human consumption. Missouri is conducting research on genetic and environmental factors which affect the quality of soybean seed for planting.

Pathologists are conducting research on the biochemical basis for disease resistance, the physiology of parasitism, mechanisms of resistance to disease, and similar problems. In addition, research is in progress to determine the essential histological and histochemical relationships in specific diseases, to determine genetic relationships in certain pathogens with respect to variability and origin of virulent strains, and to determine epidemiological relationships that will be of value in developing effective controls.

A portion of the research of these scientists is directed toward the isolation of soybean germplasm resistant to disease, such as the finding of resistance to the soybean cyst nematode in a yellow-coated soybean. Other advances are being made in resistance to the root-knot nematode, Phytophthora rot, Pythium root rot, and pod and stem blight. Recent findings on the

role of leaf beetles in transmission of pod mottle virus indicate a degree of efficiency not previously known. Other scientists are studying the pronounced synergistic effects with viruses such as mosaic and pod mottle. Two research projects are designed to provide information on pod and stem blight of soybeans which is a cause of much poor seed quality. Research is in progress on new forms and strains of the frogeye fungus so that effective controls can be developed for this disease. Several research projects are designed to determine the role of nematodes in the transmission of viruses of soybean. These are a few segments of the research program in progress at the State Stations on diseases of soybeans.

The total research effort on soybeans is approximately 23.9 professional man-years - of which 5.7 is for culture, 13.9 for breeding and genetics, and 4.3 for diseases.

PROGRESS--USDA & COOPERATIVE PROGRAMS

A. Genetics and Breeding

1. New Varieties. The variety, Wayne, was released in Illinois, Indiana, Iowa, Kansas, Missouri, and Nebraska in 1964. Wayne is adapted to the latitude of north-central Illinois. It has averaged about 3.5 bushels per acre higher in yield than existing varieties and is resistant to some important diseases. It is expected to replace varieties which occupy about 6 percent of U.S. soybean acreage.

The variety, Adelphia, was released in New Jersey. In the Middle Atlantic area where poor seed quality is a serious problem, Adelphia has superior seed quality.

Portage, a variety of extreme northern adaptation, which was evaluated in our Uniform Test program, was licensed in Canada by the University of Manitoba.

2. Cyst nematode-resistant varieties. Yellow-seeded lines resistant to cyst nematode have reached an advanced stage of development, and the first variety release is planned in 1965.

3. Breeding for disease resistance. Phytophthora rot resistance incorporation in the new variety, Wayne, is at the BC_5 generation in Illinois. Downy mildew resistance incorporation has reached BC_6 in Clark and Scott varieties, BC_4 in Chippewa and BC_2 in Wayne in Missouri. Resistance to bacterial pustule and races 1 and 2 of frogeye leaf spot is also being incorporated.

The two most serious diseases for which genetic resistance is inadequate are brown stem rot and stem canker. There appears to be tolerance, though not immunity, to these diseases.

4. Improved protein. Crosses between high protein genotypes and commercial varieties have been made. Lines have been obtained from these crosses with superior yield, but it is not yet clear that high yield and high protein can be combined in the same genotype.

The percentage of methionine, the amino acid which is first to become nutritionally limiting in soybean feeds, was not correlated with protein percentage in a large number of genotypes grown at St. Paul, Minn., and Stoneville, Miss. This is reassuring as an indication that methionine deficiency will not be intensified by an increase in protein.

5. Inheritance of traits. F_2 populations from crosses involving dt_1 and Dt_2 for determinate or indeterminate growth habit showed these genes to be at separate loci.

Evidence of a major gene affecting maturity has been obtained in backcross populations of Harosoy and Clark, two commercial varieties. In some Harosoy backcrosses, lateness is linked with tawny pubescence; in some Clark backcrosses, lateness is linked with grey pubescence.

Two genes affecting plant height, but not maturity, have been observed. One, found in a Clark backcross, is recessive and results in about 10 inches additional height. The other, found in a Harosoy backcross, is dominant and results in about 7 inches less height. Possibly these two genes are members of the same gene pair.

6. Effect of genetic traits on yield. Isoline tests showed no significant effect on yield by 5-leaflet, narrow leaflet, or oval leaflet characters. It has been suggested that narrow leaflets would be advantageous because more leaves would receive direct sunlight.

A genotype with a moderately determinate stem yielded the same as an indeterminate isoline in Illinois. A very determinate isoline yielded about 20 percent less than Harosoy, but a similar isoline of Clark yielded about 10 percent more than the parent variety. Determinate growth appears to be definitely advantageous in the South, but these results illustrate the ambiguity of performance when determinateness is varied in the North.

A gene for tolerance to high levels of phosphorus in nutrient solution had no effect on yield of Clark in initial field testing at a normal phosphorus level.

Variation in number of seeds per pod from 1.5 to 3.5 had no effect on yield in Mississippi. There was evidence in Minnesota that number of seeds per pod, as well as seed weight, may be useful early generation indicators of high yielding ability.

B. Diseases

1. Disease distribution. Diseases were less severe than in recent years, due perhaps to drouth conditions which were not favorable for optimum growth of either plant or parasite. Bacterial blight was the most commonly observed disease in Iowa and Illinois and brown spot was most common in Indiana. The largest disease index--which combines incidence, severity, and prevalence--in Indiana was that of downy mildew, in Iowa that of bacterial pustule, and in Illinois, bacterial blight. Phytophthora rot was present in Iowa, Illinois, Ohio, and the Delta. Brown stem rot is increasing.

2. Races and complexes of disease organisms. A second race of Phytophthora megasperma var. sojae was identified in Mississippi. A third race of Cercospora sojina (frogeye) was isolated in North Carolina. Some soybean varieties that are resistant to previous isolates are susceptible to the new isolates. Differences in pathogenicity of Pseudomonas glycinea isolates from many locations suggest physiologic races of this organism.

Plants doubly infected with soybean mosaic virus (SMV) and bean pod mottle virus (BPMV) were found in commercial soybean fields in North Carolina. Yield losses in doubly infected plants may depend on which virus becomes established first.

3. Phytophthora rot studies. Resistance to Phytophthora rot is associated with the production by the plant of a red substance called "phytoalexin." Phytoalexin is produced by plants of resistant varieties when inoculated with Phytophthora megasperma var. sojae, or by either Phytophthora-resistant or -susceptible varieties when inoculated with the nonpathogenic (to soybeans) P. cactorum or Helminthosporium sativum. The resistance of a plant to Phytophthora is heat-sensitive. Partial immersion of plants in a 44° C water bath for one hour destroyed resistance to Phytophthora and the ability to produce phytoalexin. Resistance was recovered after about 3 days.

Phytophthora isolates from other crop species collected in Mississippi showed little virulence on soybeans. P. megasperma from clover was slightly pathogenic, but P. erythrosptica from vetch and P. cryptogea from alfalfa were nonpathogenic to soybeans.

4. Microorganisms associated with soybeans. Several species of microorganisms are associated with soybeans in a fashion which is either nonpathogenic or is ambiguous. Several fungi, a bacterium, and a nematode were found consistently in nodules in Mississippi. Evidence of a growth-promoting effect of soil microorganisms was observed in North Carolina. Growth of plants in soil fumigated with methyl bromide was less than in unfumigated soil. Addition of nonsterile soybean roots to fumigated soil resulted in a large stimulation of plant growth.

In Maryland, some strains of actinomycetes isolated from the soil were antagonistic to some strains of Rhizobium japonicum. Antagonistic strains caused a greater reduction of nodule formation than did nonantagonistic strains.

5. Search for disease resistance. Many hundreds of genotypes have been evaluated for resistance to downy mildew, Phytophthora rot, frogeye leaf spot, bacterial pustule, bacterial blight, tobacco ring spot virus, Pythium root rot, brown spot, and brown stem rot. Resistance to the following diseases is being incorporated into desirable agronomic types by breeding: Phytophthora rot, mildew, frogeye, bacterial pustule, bacterial blight, stem canker, and brown stem rot. Resistance to the last two diseases is inadequate, but the best available is being used in the breeding program.

Organisms associated with poor seed quality were studied in Illinois, Indiana, and Delaware. Diaporthe sps. were the most prevalent. Diaporthe frequently occurs in seed of poor quality, but neither cause-and-effect relationships nor conditions which favor growth of the organisms have been resolved.

6. Methodology. A new method of identifying bacterial pathogens through use of fluorescent-labelled antibodies and microscopic examination appears very promising. Antisera specific for a given pathogen make it possible to quickly identify the organism in a mixed culture. If this method fulfills its promise, it will greatly reduce time and space requirements and increase precision of pathogen identification.

7. Rotation practices in disease control. Rotation with corn apparently gave control of brown stem rot in Iowa. Yields where soybeans followed 5 years of corn were more than double the yields in continuous soybeans. Cooperative studies with Crops Protection Branch at Ridgely, Tennessee, have shown that rotation is a promising control measure for cyst nematode.

C. Quality and variety evaluation.

1. Chemical methods. The applicability of nuclear magnetic resonance (NMR) for measurement of oil is being studied. This is a rapid, non-destructive method, which can be used on single seeds or on up to 25 grams of seeds or meal. NMR values of standard samples of soybean seeds ranging in oil content from 8% to 26% by official methods show a linear relationship to oil percentage. The relationship of NMR value to oil percentage is being studied in a large number of Uniform Test samples to determine whether the linearity is sufficiently precise over the narrow range of oil content in these samples.

Gas-liquid-chromatography is being used in surveying the germ plasm collection for sources of low linolenic acid. About 1400 genotypes have been analyzed for linolenic and linoleic acid. None has had linolenic acid below 4% and very few below 5%. These values are not low enough

for a good low-linolenic acid breeding program.

2. Factors influencing oil and protein. Oil percentage in Jackson soybeans in a Florida study was positively associated with yield and negatively with weight per seed. Protein percentage was negatively associated with both yield and weight per seed. 84% of the variation in oil and about 75% of the variation in protein was accounted for by these relationships.

D. Cultural and harvesting practices

1. Inoculation. Inoculation techniques have been studied in Iowa, Maryland, Mississippi, and Florida. Strains of Rhizobium japonicum differed in their ability to survive, produce nodules, and fix nitrogen. Very poor recovery of applied strains was obtained, indicating that most nodules resulted from bacteria present in the soil. Many different methods of applying inoculum were tried. There was a suggestion that applying inoculum at 25- to 50-times the normal rate with appropriate adhesives might increase the recovery of the applied strain.

A Rhizobium strain test in Mississippi on soil with no known history of soybean production was inconclusive because uninoculated checks were well-nodulated and yielded more than the average of inoculated treatments. However, in Florida a significant interaction of Rhizobium strains and soybean varieties was obtained in an experiment involving eight Rhizobium strains and four soybean varieties.

Resistance of R. japonicum strains to antimicrobial agents is not uncommon. Fifteen strains were tested against 19 antimicrobial agents. All strains were resistant to 6 and susceptible to 3 agents at both of the test concentrations. Differential susceptibilities to the other 10 agents seemed to be related to serological characteristics of the strains.

2. TIBA. Tri-iodobenzoic acid has increased soybean yields in some tests in Iowa. It was tested in Indiana, Illinois, and Missouri in 1964 on several varieties. Results included both decreases and increases in variety yields. Present evidence as to the usefulness of TIBA on a commercial scale is inconclusive. There is some indication that its potential will be enhanced if narrower rows are used.

Other plant growth regulators have also been suggested as of possible value in soybean production.

E. Physiology

1. Nutrient relationships. Reciprocal grafts showed that the phosphorus-sensitive or phosphorus-tolerant character of a variety is largely controlled in the roots. Tolerant tops reacted as sensitive plants when grafted to sensitive roots, and vice versa.

An apparatus for study of nitrogen nutrition under controlled nutrient conditions has been established in the field. A low level of nitrogen in the nutrient solution is necessary to meet nitrogen requirements until the nodule system becomes operative. However, seed yield was unaffected by variation in external nitrogen supply levels from 22 to 88 ppm. There was no significant yield response to various amounts and methods of application of the following forms of nitrogen: Plastic-coated urea, uncoated pelleted urea, ammonium nitrate or ammonium sulfate. All of these results suggest that nitrogen in the forms offered did not effectively add to that available through the nodules.

Dry matter accumulated in soybean plants at a maximum rate of about 125 pounds per day and in the seed at about 100 pounds per day per acre. Maximum rates and duration of dry matter accumulation in the seed varied among varieties. The variation in both maximum rate and duration contributed to differences in seed yields. There is indication that genotypes with a "thin" silhouette concentrate a greater portion of total dry weight in the seed than those with a "fat" silhouette. "Fatness" or "thinness" is an expression of leaflet shape, petiole length, branching, etc. It is not yet clear whether these data are in agreement or conflict with evidence that variation in leaflet shape has little or no significance with regard to yield.

2. Metabolic studies. Nitrate reductase (NR) appeared to be more stable in soybeans than in other plants where it has been studied. NR level was not indicative of physiological age, nor did it reflect solution N level, as was expected since it is said to be an adaptive enzyme. Soybean NR has been isolated in the chloroplast fraction of cell homogenates. This will facilitate further study of the significance of this enzyme in nitrogen metabolism of soybeans.

Fat synthesis was studied in immature soybean seeds by the incorporation of acetate-1-C^{14} into lipids. About two-thirds of the fat synthesis activity was oxygen dependent. The substance which accumulated the most radioactivity during two-hour experimental periods appeared to be malonic acid, implying the presence of the conventional "fatty acid synthetase" system. A sharp maximum in rate of fat synthesis in seeds of 75-100 mg dry weight has been observed, but requires confirmation.

3. Environmental studies. The significance of lodging on light penetration into the plant canopy and in turn on yield potential is under study. Results suggest that a moderate degree of lodging is associated with greater seed production than either erectness or severe lodging.

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OILSEED CULTURE, BREEDING, DISEASES AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. The urgent need in safflower is higher yield of seed, lower hull percentage with consequent higher oil and protein content, and rust-resistant varieties for irrigated production in the Great Plains.

For peanuts, more precise information is needed on: (1) The nature and control of diseases with special emphasis on mold toxicity and soil borne diseases; (2) the physiology of the plant, mineral nutrition, and environmental factors affecting growth, and flowering and fruiting; (3) breeding behavior of the crop; and (4) identifying and measuring characteristics of peanuts associated with quality for specific end uses. Improved varieties with higher yield, resistance to diseases and insects, adaptation to mechanical harvesting, increased market acceptability, and enhanced nutritional and keeping properties are urgently needed.

The most urgent problem in flax is the breeding of improved varieties with higher yield of seed and high oil content. The germplasm of current varieties has been explored and there is little evidence further appreciable advance can be made without the introduction of new genes from the World Collection or from related wild species. An attempt is planned to exploit sources of possible new and advantageous genes through increased natural crossing of entries in the World Collection accelerated by irradiation-induced male sterility.

The basic technique in producing commercial F_1 castorbean seed by using the environmental sensitive type of pistillateness has been developed. Improved inbred lines with good combining ability that will produce disease-resistant F_1 hybrids with high oil percentage are needed.

The hand labor required in harvesting and threshing dehiscent sesame varieties have proved a limiting factor in production. Although great progress has been made in developing indehiscent varieties adapted to complete mechanized production, further improvement in both seed yield and quality must be obtained before the crop can be grown profitably over a wide area.

Limiting factors in sunflower production are lack of varieties resistant to insects and disease. The introduction of varieties with increased oil content of the seed, the proven possibility of increased yield through F_1 hybrids, and the hope of finding disease and insect resistance should make commercial production more profitable.

Methods are needed, either chemically to keep tung trees dormant to avoid spring frosts, nutritionally or culturally to make trees more cold hardy, or through breeding to find or develop more cold hardy or later blooming clones. In some years, the disease Mycosphaerella leaf spot defoliates trees early

reducing oil content. Control for this disease is needed. More information on spacing, nutrition, cultural practices, and variety testing is needed to enable more consistent and higher production at less cost.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, pathologists, biochemists, physiologists, agronomists, and horticulturists engaged in both basic and applied research leading to the solution of growers' problems. Safflower breeding, disease, and cultural research is being carried on in cooperation with the California, Utah, Arizona, and Nebraska Agricultural Experiment Stations and at Beltsville, Maryland. The nature of resistance to safflower diseases is being investigated at Davis, California, under cooperative agreement with the California Agricultural Experiment Station. Peanut breeding and variety evaluation research and peanut disease investigations are cooperative with the Georgia Agricultural Experiment Stations. Disease, culture, seed physiology, and variety evaluation research are cooperative with the Alabama Agricultural Experiment Station. Peanut disease and variety evaluation research are cooperative with the Virginia Agricultural Experiment Station. Peanut variety evaluation and seed physiology research are carried on at Beltsville, Maryland. Peanut rust and variety and strain adaptation research are carried on at Mayaguez, Puerto Rico. Research on range of genetic variability in tocopherols of diverse peanut germ plasm is being conducted under contract at Menlo Park, California. Peanut research is being conducted under 3 5-year PL 480 contracts. One in India covers range of genetic variability in U.S. and India's diverse peanut germ plasm. Another in India involves physiology of cell particulates. The third in Israel is a study of the biology of the fungus Aspergillus flavus as it affects peanuts. Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations, and at the Southwestern Irrigation Field Station, Brawley, California. The nature of resistance to rust is being studied under contract with the North Dakota Agricultural Experiment Station. Castorbean breeding and genetics, disease control, and cultural trials are conducted in cooperation with the California, Texas, and Mississippi Agricultural Experiment Stations, and at Beltsville, Maryland. Sesame research is conducted in cooperation with the Texas and Mississippi Agricultural Experiment Stations and at Beltsville, Maryland. A limited program of sunflower research is conducted in cooperation with the Texas Agricultural Experiment Station. The Department has a continuing long-term program of tung research carried on at one central field location at Bogalusa, Louisiana, with a field laboratory at Cairo, Georgia. The work is cooperative with the experiment stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Missouri Experimental Tung Farm, Poplarville, Mississippi.

The Federal scientific effort devoted to research in this area totals 34.8 professional man-years. Of this number 10.9 are devoted to genetics and breeding; 8.8 to diseases; 3.6 to variety evaluation; and 11.5 to culture.

PROGRAM OF THE STATE EXPERIMENT STATIONS

Scientists at the State Stations are conducting research on all of the primary disease problems of oilseed crops. Many of the diseases of these crops contribute heavily to low yields and poor quality, and in some instances, are a major limiting factor in their production. Some research projects involve the isolation of germplasm resistant to specific diseases, which can be used by plant breeders and others for improvement of these crops.

Research on diseases of flax involve studies on the destructive rust and seedling blight problems. The biochemical specifics of resistance in flax to rust is providing new knowledge on metabolic pathways in the disease process, on enzymatic patents such as those involved in epoxy-stearic acid synthesis, and on other areas of disease physiology. Studies are also being conducted on the use of chemicals in the control of flaxrust. Seedling blight of flax is being investigated with emphasis being placed on the role of crop sequence and residues in control of the disease. A few research projects are designed to provide new knowledge on diseases of safflower, sunflower, and sesame, such as fusarial wilt, rust, bacterial blight, Verticillium wilt, and root rots. Castorbean diseases are being studied at several locations. New findings on Alternaria leaf spot of castorbean have demonstrated the breakdown of resistance in new varieties, and thus provide a better basis for eventually obtaining effective control of this disease. Seed diseases and seedling blights of castorbean are also being investigated.

Scientists at the State Stations are providing leadership in research on the disease problems involved in the culture, harvesting, and processing of peanuts. Several scientists are concerned with the role of nematodes in diseases of this crop. Through one project special attention is given to the cyst-forming species which have been discovered in certain peanut areas in recent years. Other investigations on nemas in peanuts are designed to provide knowledge on the root knot problem, the interaction of nemas and other disease agents, their role in the black hull problem, and the use of chemical and biological systems for their control.

A pressing pathological-microbiological problem in peanut culture, both in this country and in other parts of the world where this product is produced or used, is that of mycotoxins and, specifically, aflatoxins. Scientists at eight of the State Stations have concentrated their efforts on this problem facing the peanut industry and are providing significant contributions through their leadership in this research. Other government agencies, including the Department of Agriculture, and industry cooperate in some phases of this work. Progress in this research has recently been summarized in joint meetings with all institutions and agencies concerned.

The total research effort on oilseeds is approximately 11.1 professional man-years; of which 0.5 is for culture, 5.3 for breeding, and 5.3 for disease.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

A. Breeding and Genetics

1. Safflower. Unfavorable weather and lower price for the oil has drastically reduced safflower acreage in western Nebraska and adjacent areas to the point where profitable mill operation is impossible. A base acreage grown on irrigated land would provide sufficient seed to permit operation of the mill even in years when nonirrigated production was low. Profitable production as an irrigated crop depends upon rust-resistant varieties capable of high yields to compete with other crops grown in the area. The variety Ute, moderately resistant to rust, has been released and is being extensively tested under irrigation in the area.

New sources of rust resistance have been found in introductions and are being bred into selections with commercial promise.

The variety A0104, developed cooperatively by ARS and the Arizona Agricultural Experiment Station, continued to yield more than Gila and had higher oil content and protein content of the meal.

The striped hull experimental varieties 21417 and A101, developed cooperatively by ARS and the Arizona Agricultural Experiment Station, proved to have objectionable oil color and probably will not be released. Both varieties were exceptionally high in oil. A few selections without the objectionable pigment are being tested for possible use in breeding lines and show considerable promise.

2. Peanuts. Natural crossing appears to be general in Southeast. Evidence of uni-directional natural crossing, obtained by use of seedling genetic market at 5 research locations in the 3 Southeastern Peanut Belt States during 1964, indicates that the low but persistent level of natural outcrossing observed at Tifton, Georgia, for several years is probably typical for the Georgia-Florida-Alabama area.

Bees are probably responsible for natural crossing. Additional circumstantial evidence has been obtained indicating that bees are probably responsible for natural outcrossing of peanuts. No outcrossing occurred in 1963 or 1964 when bees were excluded from flowering peanuts at Tifton, Georgia.

3. Flax. As a result of 3 years of testing in Regional Uniform Nurseries, a selection from the cross of Redwood X Crystal has proved outstanding in yield and oil content. It is resistant to diseases and is being considered for release as a commercial variety. A new wilt-resistant variety, Dunes, was released for irrigated production in California and Arizona. This variety is comparable to New River or Imperial in yield but has much higher oil percentage. Dillman, a new winter-type flax was released in Texas. This is an exceptionally cold-tolerant variety, high-yielding, and resistant to rust.

The possibility of producing hybrid flax by using cytoplasmic male sterility is being investigated. One of several serious problems seems to be solved with the discovery of superior fertility restorer genes in recent introductions from Greece.

A profuse branching character which results from a recessive gene was found to have a pronounced effect upon seed yield. F_2 plants possessing the branching character produced much more seed than F_2 plants lacking the branching character.

4. Castorbean. In combining ability studies at Davis and Shafter, California, including 28 hybrids, both general and specific combining ability were shown for yield. This fact together with significant interactions for locality point out the complexity of selection for yield and the necessity for testing large numbers of hybrid combinations under different environments. General combining ability was most important for oil percentage. Hybrid by location interaction was nonsignificant indicating that selection for oil percentage may be done at one or only a few locations.

The female line CNES-1, requiring little or no roguing of monoecious plants in the commercial production of hybrid seed, was released to castorbean breeders.

A large number of breeding lines having resistance to both capsule mold and capsule drop have been developed at Stoneville, Mississippi. These lines show considerable promise to prevent losses from these diseases in commercial production on the High Plains of Texas.

5. Sesame. The indehiscent variety, Baco, performed satisfactorily in certified seed production fields, and considerable increase in acreage of this variety may be expected. A new indehiscent variety, Paloma, was released. Capsules of Paloma open gradually allowing the seed to shatter over a considerable period of time, thus providing winter food for birds. Paloma appears to be widely adapted and may be useful as a variety for direct combine harvest of seed for industrial use. In 14 regional trials in 5 States, Baco and Paloma yielded 824 and 748 pounds seed per acre, respectively, compared with 831 for Margo, the indehiscent check.

Resistance to race 2 of bacterial leafspot has been added to lines of the Margo type that are equal or superior to Margo in seed yield and agronomic type.

6. Sunflowers. F_1 sunflower hybrids frequently show increased vigor and yield resulting from heterosis. The rust-resistant hybrid, T56002, is widely adapted and has produced approximately 30 percent more than the more common inbred varieties. Parental lines for the production of T56002 were released. The female line, S-37-388T, is largely self-incompatible and is rust susceptible. Lines HA6, HA7, and HA43 are rust resistant, self-compatible, and used as male parents.

Self-incompatability is a desirable character in lines of sunflower to be used as females in F_1 hybrid production because there is no practical way to emasculate the flowers on a large scale. Complete self-incompatability would preclude maintaining a line as an inbred. Genetic studies of the heritability of this character indicate that a usable degree of self-incompatability can be attained so that an inbred line may be grown in isolation to produce inbred seed, but still is sufficiently incompatible to produce a high percentage of hybrid seed when grown in crossing blocks.

7. Tung. Breeding for late-flowering habit. Eight additional trees were located in 1964 which blossomed 17 days after Isabel. Five of the 9 late-flowering selections located in 1963 blossomed 3 to 10 days after Isabel. To study the nature of the late-blossoming character, resistance to forcing at 80° F. of blossom buds of these selections and standard varieties was determined. Isabel and Lampton buds chilled 6 days at 41° F. began growing after 53 days forcing. Where chilled for 32 days they began growing after 24 days forcing. Buds of 2 late-flowering selections failed to grow after 69 days forcing and less than 32 days chilling.

At Compass Lake, Florida, G-61 and F-732 seedlings show promise of giving the lateness of blossoming desired in a breeding program.

Seedlings from open-pollinated seed of selection F-732 planted at Compass Lake, Florida, in 1961, blossomed uniformly late in 1964. This was the first crop for these plants and the uniform results indicate a high degree of homozygosity for this character.

Interspecific hybridization. A study of meiosis in hybrids between Aleurites fordii and A. montana showed complete lack of pairing of chromosomes and very irregular distribution (of chromosomes) at anaphase I. This lack of homology could account for high sterility of the hybrids.

Breeding for disease resistance. Approximately 4% of the plants in three nurseries containing 63 progenies were selected as having high resistance to angular leaf spot. The entire progeny of one cross appeared to be resistant. The material must undergo further screening to eliminate plants escaping inoculation.

B. Diseases

1. Safflower. Rust. Eighteen safflower introductions originally selected as highly resistant have remained so in repeated trials under favorable conditions for the development of physiologic races of the rust fungus. These lines are diverse in country of origin and characteristics and are believed to represent different sources of rust resistance. Genetic studies are being conducted to determine the inheritance of rust resistance from several of these introductions.

Phytophthora. Studies of the nature of the "Biggs" seedling resistance to Phytophthora indicate that the amounts of water-insoluble pectic substances and calcium in the fresh tissue are related to resistance, the less resistant seedlings being higher in water. The relationship of pectic substances and calcium contents to resistance did not hold when these compounds were expressed on a dry weight basis.

Viruses. Lettuce mosaic virus was shown to be the cause of a necrotic condition of a commercial safflower variety and related lines. This is the first report of this virus attacking safflower. Leading varieties grown commercially appear to be resistant. A disease causing yellowing of the leaves and stunting and death of the plants in Arizona in 1964 is believed to be caused by a virus. This disease is sporadic in nature and varies greatly in importance from year to year.

Fusarium. Fusarium wilt of safflower has been serious in limited areas in California. The variety N6 has been resistant and is being used to breed resistant varieties. However, an isolate was obtained from an N6 plant that attacks N6 and appears to be a new pathogenic strain.

2. Peanut. Additional landplaster suppressed peanut pod rot. Landplaster at the rates of 1500 and 3000 pounds per acre significantly reduced pod rot and increased pod yield and market quality of peanuts at Holland, Virginia, in 1964. Of 2 chemicals used in conjunction with landplaster at 1000 pounds per acre, one reduced pod rot and increased yield; the other did not. When used in conjunction with landplaster at 1000 pounds per acre, cover crops influenced the extent of pod rot differentially but had no significant effect on yield.

Oats suppressed Sclerotium rolfsii. In research at Auburn, Alabama, on the influence of plant residues on Sclerotium rolfsii, which causes stem rot or southern blight of peanuts, sterile extracts of oat and corn residues inhibited the growth of the fungus. Extracts of crimson clover, peanut, and vetch had little effect. Oat residue added to natural soil inhibited germination of sclerotia, promoted rapid destruction of mycelium of the pathogen, and suppressed development of stem rot of peanut seedlings growing in S. rolfsii-infested soil in the greenhouse.

Temperature and relative humidity have striking effect on spread of peanut leafspots, according to results of cooperative research in Georgia. Cercospora leafspots were observed to increase very rapidly when the relative humidity stayed at or above 95% for 10 or more hours per day and the temperature was 75° or above for a good part of the period. Possibility of scheduling applications of fungicides in relation to meterological conditions to effect maximum degree of control of Cercospora leafspots at minimum cost is under investigation.

Toxin-producing strains of Aspergillus flavus are present in Virginia. Results of cooperative research at Holland, Virginia, showed that a small

percentage of pods of Spanish-and Virginia-type peanuts were infected with A. flavus prior to digging. Most of the isolates of this fungus were found to have a capacity for producing aflatoxin when grown on peanut seed and other substrates under conditions favorable for toxin production.

Toxin-producing strains of Aspergillus flavus are prevalent in Israel. Results of PL 480 research, cosponsored by Market Quality Research Division, show that seed-borne fungi of peanut seed stored in shell and as shelled seed in Israel were similar to those in this country, with Aspergillus niger predominating. A. flavus was on seed of 80 percent of pod samples and on 100 percent of shelled samples, constituting 7 percent of mycoflora of unshelled seed and 15 percent of that of shelled seed. A. flavus was found in soil of all peanut fields examined. Eighty percent of cultures of A. flavus gave a positive chemical test for aflatoxin.

Certain wild species of peanuts appear immune to rust. In Puerto Rico none of more than 1100 entries of the cultivated peanut, Arachis hypogaea, was found to be appreciably resistant to rust. Defoliation of plants by rust tended to occur earlier for early maturing varieties than for later maturing varieties. Three entries showed some indications of partial resistance or tolerance to rust. Of more than 25 accessions of wild species of Arachis, only 3, identified as A. monticola, showed a modest susceptibility, whereas, the others appeared immune to strains of the rust in Puerto Rico.

3. Flax. Rust. The widely accepted use in 1964 of varieties of flax known to be resistant to the new race of rust attacking many commercial varieties resulted in negligible loss in 1964. The new race spread through much of the flax region in Minnesota and the Dakotas on susceptible varieties indicating it could be destructive if resistant varieties were not grown. Field collections of rust show evidence of hybridization of the new race 300 with previously known races giving rise to new combinations of genes for pathogenicity. Bolley, B-5128, Redwood, Summit, Windom, and Norland, all in commercial production are resistant.

Studies of the reaction of new introductions to selected rust races indicate 11 introductions may carry new sources of resistance. The identification of these new sources may prove extremely important in breeding resistant flax varieties.

Diffusate collected from the surface of leaves inoculated with an avirulent race was more inhibitory to urediospore germination than diffusate from the surface of leaves inoculated with a virulent race. Diffusate from uninoculated leaves had no inhibitory effect. These results suggest the formation of a toxin in the leaf in response to invasion by the rust hyphae. Inoculation of flax plants cause a change in respiration rate. In resistant plants, there is a sudden rise to approximately 170 percent of the control followed by a decline to near normal in 6 days. In susceptible plants, the rate rises to 130 percent of control during the first 24 hours and falls to 80 to 90 percent during the next 4 days. During the 6th day the respiration rate

rises to approximately 170 percent of normal.

4. Castorbean. Capsule mold and capsule drop commonly cause losses up to 75% on susceptible varieties in the humid South. The organisms causing mold and drop are not definitely known. Resistance was found in one commercial variety and one wild plant found in Mississippi. Using these sources of resistance, breeding lines with a remarkable degree of resistance have been developed. These lines are resistant to capsule mold in the major area of production on the High Plains of Texas and are being used in breeding varieties and hybrids for the area.

Botrytis. This fungus may attack and destroy castorbean capsules. The breeding lines developed in Mississippi for resistance to capsule mold and capsule drop are also resistant to Botrytis. One of these lines, M1935-5, is superior to all other lines studied. Resistance is apparently due to the high resistance of the capsule pericarp to maceration by peptic enzymes.

5. Sesame. Verticillium wilt. In variety tests at Lubbock, Texas, varieties differed greatly in susceptibility to Verticillium ranging from 1 to 48 percent. Apparently breeding for resistance to this disease would be effective.

Fusarium wilt. As a result of a 4-year trial in South Carolina, resistance to Fusarium was not consistent, but there is adequate evidence to show that breeding for resistance would be successful.

Red root. The cause of red root disease found at Beltsville, Maryland, and Muleshoe, Texas, was identified as Thielaviopsis basicola.

6. Sunflower. Rust. New, or different, races of rust continue to appear. Leaves of hybrid T56002 which previously never had exhibited more than a trace of rust at College Station, Texas, had up to 5 percent infection in 1964. This hybrid is effectively resistant at most locations, but was severely attacked at Pontiac, South Carolina, where no wild sunflowers or other sources of inoculum could be found.

7. Tung. Angular leaf spot. (Mycosphaerella aleuritidis). Etiology studies were made on single terminal leaves at 3, 9, and 15 feet above ground by spraying with LO-3274 oil 5 times at 3 week intervals. By midsummer, the number of spots - due to ascospore infections - on the sprayed leaves nearest the ground was significantly lower than the unsprayed check leaves. Data followed identical pattern for intermediate level, but were inconsistent at highest level.

C. Varietal Evaluation

1. Safflower. A new variety, Ute, with a moderate degree of rust resistance has been released in cooperation with the Utah Agricultural Experiment Station. This variety will be tested extensively for production under

irrigation in Western Nebraska and adjacent areas in Colorado and Wyoming. As an average of 14 irrigated trials in 10 states, Ute yielded an average of 2458 pounds per acre compared with 2216 pounds for Gila. In 19 non-irrigated trials in 10 States and 1 Canadian province, Ute yielded an average of 1048 pounds and Gila 1119 pounds per acre.

The experimental variety, A0104, was tested in Arizona and produced an average of 3756 pounds of seed compared with 3368 pounds for Gila. Oil content of the two varieties was 39.6 and 36.6 percent, respectively.

2. Peanut. Potential new variety appears promising. Georgia 186-28, a highly productive new peanut of the Runner market type, developed in co-operation with the Georgia Experiment Stations, is in the final stages of evaluation for possible release to growers. The agronomic superiority of Georgia 186-28 to other Runners now grown commercially has been established in regional variety tests in Georgia, Alabama, and Florida. Its market acceptability is now under investigation. Initial reports on shelling properties and processing quality have been favorable.

Recent peanut introductions from foreign countries continue to show promise. Of more than 800 recent peanut introductions or selections therefrom in initial to third cycle agronomic evaluation tests in Georgia, Alabama, and New Mexico in 1964, more than 15 percent outyielded standard commercial check varieties.

3. Flax. The experimental variety, C.I. 2290, has averaged higher in yield for the 1962-64 period than any commercial variety or other experimental line in Minnesota. Oil content is higher than any commercial variety except Bolley. Thirty-three rust-resistant varieties were grown in State-wide tests in Minnesota. On the basis of seed yield, oil content, and disease reaction, four lines were outstanding in performance.

Mixtures of flax varieties continue to yield more than the average of their yields when sown alone in Minnesota. The increased yield ranged from 1.2 percent in high yielding trials to 12 percent in the lowest yielding trials. These data together with similar results in previous trials indicate that breeding for a high degree of uniformity may not be advantageous.

4. Castorbean. Hybrids using Lynn and Hale as male parents were usually highest in yield in the Lubbock-Plainview area of Texas. These two varieties and hybrids in which they are male parents will be planted on a large portion of the commercial acreage in Texas in 1965.

5. Sesame. Data from 16 regional sesame trials show average yields over 900 pounds per acre at 7 locations, over 1000 pounds at 5 locations, and over 2000 pounds at Stoneville, Mississippi. Dehiscent varieties yielded more than the indehiscent varieties. Baco was the highest yielding indehiscent variety.

A combine trial in a field of certified Baco at Muleshoe, Texas, demonstrated this variety can be harvested by direct combining 6 weeks after the plants were killed by frost. Germination was lowered as a result of seed injury from the combine from 99 percent for hand-harvested seed to 83 and 74 percent for seed harvested at combine cylinder speeds of 500 and 800 rpm, respectively.

D. Culture and Physiology

1. Safflower. Fertilizer trial. Application of nitrogen fertilizer increased yields of safflower at Mesa, Arizona, from 1535 pounds per acre for the check to 3900 pounds for 150 pounds of N from ammonium nitrate. More favorable results were obtained by dividing the fertilizer into 2 or 3 applications with above 1/2 the amount broadcast preplant, and the remainder either in March or in March and April. Urea at 150 pounds of N per acre was toxic and severely injured the safflower plants.

2. Peanut. Production environment and genotype having a striking influence on peanut fatty acids. Additional evidence shows that a wide variation exists in fatty acid composition of oil of mature seed of different types and varieties of peanuts and that the fatty acid composition of apparently mature seed can be influenced strikingly by the environmental conditions under which the seed are grown. Genotype-environment interactions for fatty acid content appear much greater within Virginia-type varieties than within the Spanish-Valencia group.

Tocopherol content of peanut germ plasm is under study. In contract research, an improved method has been developed for the quantitative determination of individual tocopherols in oil of peanuts as a prerequisite to determining the range of genetic variability in tocopherol content of seed of our peanut germ plasm and relating this to keeping quality of the seed.

Range of genetic variability in chemical composition of peanuts is being studied. In PL 480 research on the range of genetic variability in our and India's extensive peanut germ plasm in oil, protein, and constituent fatty acids and amino acids, 100 selected entries from U.S. and 100 from India were grown in 1964 at both Tifton, Georgia, and Ludhiana, India, with planting dates so staggered that all entries at each location went through the critical stage of pod and seed development simultaneously and were dug, cured, and handled under comparable conditions. Pod samples from Tifton were sent to Ludhiana where all pod samples were handshelled, and apparently fully mature seed were selected for analysis. Chemical analysis of these samples is proceeding.

3. Flax. Lipid metabolism. Controlled environmental studies in which temperature was the sole variable have shown that flax growth, seed production, and oil formation are markedly influenced by temperature during the period of boll formation. Fatty acid composition was most sensitive to temperature. The temperature treatment with the least effect on seed development caused a slight increase in the quantity of oleic acid synthesized

but did not alter the level of the other acids. As response to temperature increased, reductions in the weights of polyunsaturated acids were observed along with the increase in oleic acid; and finally, production of all acids was retarded, and seed weight and oil content were depressed. During the first 2 weeks after flowering, an increase in temperature from 15° to 20° C. enhanced the formation of polyunsaturated acids, but during the 3rd and 4th weeks, a depression in levels of linolenic acid became pronounced. Reduction in synthesis of polyunsaturated acids in the later stages of seed development in part paralleled the hastened maturation caused by increased temperature.

Effect of removing bolls. Removing as many as 15 bolls from the plant immediately after pollination caused no reduction in the total bolls per plant at maturity, total weight of seed per plant, seeds per boll or seed weight. Removal of later bolls was injurious to boll development.

4. Castorbean. Root penetration. It was demonstrated that castorbean roots penetrate to at least 40 inches and absorb plant food and moisture from that depth. Roots of Hale castorbean penetrated to a depth of 40 inches in irrigated Amarillo loam and absorbed radioactive P^{32} in approximately 75 days. Time required for the roots to reach other depths were approximately: 30 inches, 65 days; 20 inches, 43 days; 10 inches, 39 days.

5. Sesame. Weed control. Studies of weed control methods in sesame were conducted in cooperation with Crops Protection Research Branch, ARS, at Stoneville, Mississippi. Excellent weed control was obtained by a preemergence treatment with isopropyl N-(3-chlorophenol) carbamate (CIPC) at 6 lb/A after planting on June 2 and post emergence of 8 lb/A after the final cultivation on July 25.

6. Tung. Dormancy. Four additional chemicals retarded blossoming of buds on cut shoots artificially forced in the laboratory. At present, 12 chemicals appear to have potential value as blossom retardants. Of these, 2-thiopacil has given best results.

At Compass Lake, Florida, broadcast applications of calcium and magnesium sources significantly increased the cross section area of tree trunks grown on soils deficient in these elements. There was no effect on yields in these experiments.

Soil moisture. Deficient soil moisture reduced the synthesis and storage of oil in the tung fruit.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Breeding and Genetics

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WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on oilseeds and peanuts.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross-commodity in nature. The total Federal scientific effort devoted to weed control involves 78.2 professional man-years' effort. Of this total 5.7 is specifically directed to weed control in oilseeds and peanuts.

The Department has a long-term continuing program of basic and applied research on various phases of nematology which contribute information of value to nematode control. In the past few years, as State nematology programs have developed there has been increased emphasis on basic research by the Department. Basic research on nematode taxonomy and physiology is located in Beltsville, Maryland, while 13 field stations combine applied and basic research in varying proportions. Research on nematodes affecting oilseeds and peanuts is conducted at Tempe, Arizona; Auburn, Alabama; Tifron, Georgia; Urbana, Illinois; Beltsville, Maryland; and Jackson, Tennessee.

The Federal scientific effort devoted to research in this area in F.Y. 1965 totaled 27.3 man-years. Of this, 13.0 were devoted to basic research on nematodes and 2.3 to oilseeds and peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical plants and soils.

Nematology research programs are actively pursued in 47 States and Puerto Rico. Collectively, this well-organized research program is supported not only by the institutions involved but also by such agencies as the National Science Foundation, National Institutes of Health, private institutes, foundations, and industry. Fundamental investigations in nematology continue to receive major emphasis by State scientists.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

I. Weed Control

a. Soybeans

Under the droughty conditions of 1964, at Stoneville, Mississippi, amiben provided generally better control than linuron, trifluralin, or R-1607. None of the preemergence herbicides evaluated provided adequate control of large seeded weeds such as cocklebur and coffeeweed under limited rainfall. Postemergence applications of diuron and herbicidal oil gave effective and economical postemergence weed control in soybeans if excessive drought or rainfall did not prevent timely application. Postemergence application of 2,4-D to cocklebur plants in soybeans provided good to excellent control with little to moderate crop injury. Coffeeweed was effectively controlled in soybeans with an amine form of 2,4-D in wax bars with no appreciable injury to soybeans. This treatment probably will be used on several thousand acres in the lower Mississippi River Delta. Excellent control of annual weeds with acceptable soybean tolerance was obtained with (a) pentachlorophenol (PCP) at 16 lb/A, (b) PCP at 8 lb/A + N-1-naphthylphthalamic acid (NPA) at 2 lb/A, (c) PCP at 8 lb/A + NPA at 3 lb/A, (d) DCPA at 4 lb/A + 4,6-dinitro-o-sec-butylphenol (DNBP) at 1.5 lb/A, and (e) O-(2,4-dichlorophenyl)-O-methyl isopropylphosphoramidothioate (DMPA) at 6 lb/A + DNBP at 3 lb/A in Georgia. The DMPA-DNBP mixture apparently increased the yield of soybeans.

b. Peanuts

At Tifton, Georgia, subsurface placement or disk-incorporation gave effective control of nutsedge in peanuts in 1964. In previous years, disking was erratic. Deep subsurface placement (3 inches) of EPTC or PPTC and shallow planting (1.5 inches) of peanuts gave essentially the same results as shallow herbicide placement and deep planting. For the third consec-

utive year, a mixture of DMPA at 6 + DNBP at 3 lb/A, applied at the ground cracking stage, gave a significant increase in yield of peanuts. Market quality, germination, organoleptic, and chemical evaluations indicated that there were no adverse effects from herbicides.

c. Other Oilseed and Industrial Crops

Safflower. Soil-incorporated, preplanting CIPC, IPC, or EPTC gave the best control of annual weeds in safflower. Postemergence applications of diuron did not significantly reduce seed yields of safflower in Arizona.

II. Nematode Control

Oilseeds. Field and laboratory studies at Jackson, Tennessee, indicate that soybean varieties such as Illsoy, which are moderately resistant to the soybean-cyst nematode, do not allow increase of this nematode under field conditions anymore than the highly resistant varieties NC-55 and Peking. Soybean varieties were evaluated for multiple nematode resistance. 'Delmar' was resistant to M. incognita incognita, M. incognita acrita, and M. hapla; Lee and NC-55 were not resistant. Selection #29 was resistant to the soybean-cyst nematode and also had a high degree of resistance to root-knot nematodes. Greenhouse studies of soybean-cyst nematode populations obtained from six States indicate that there are biological strains of the soybean-cyst nematode. Although the data are not conclusive, the results of several tests made in 1963 and 1964 indicate that the cyst nematode populations from Virginia do not build up on Lee soybean as fast as populations obtained from Arkansas, Missouri, Tennessee, North Carolina, and Mississippi.

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SOYBEAN AND PEANUT INSECTS
Entomology Research Division, ARS

Problem. Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. Basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resist crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA AND COOPERATIVE PROGRAM

The Department has a limited program involving basic and applied research on the insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists, and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations.

The Federal scientific effort devoted to research in this area totals 1.5 professional man-years. Of this number 0.3 man-year is devoted to basic biology; 0.3 to insecticidal control; 0.5 to insecticidal residue determinations; and 0.1 to biological control; 0.1 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases; and 0.1 to program leadership.

PROGRAM OF THE STATE EXPERIMENT STATIONS

The States have an active program of research on soybean and peanut insects.

On soybeans, research is in progress to determine the amount and type of injury caused by various species of insects. Life histories and habits are studied under varied temperature and humidity conditions in the laboratory. Periodic field surveys are conducted to determine variations in seasonal population levels of insects on soybeans and other host plants. Control treatments are applied at different times through the season to establish population levels necessary to cause significant damage.

Peanut insect research is concerned with seasonal history and habits of insect pests, determining economic infestation levels, chemical and cultural control and plant resistance studies. Biological information is being obtained as a basis for developing control programs. Rearing methods have been worked out for the most damaging species. Pests which appear sporadically are being studied to determine the factors responsible for outbreaks and the extent of injury they cause. Chemical controls and effects of tillage, irrigation and other management practices are evaluated under field conditions. The appearance of resistance in the southern corn rootworm to commonly used insecticides has necessitated intensification of non-chemical control research. Extensive comparisons of peanut introduction lines are being made and plants which exhibit resistance to insects are selected for further study and possible use in breeding programs.

There are 6.1 professional man-years devoted to soybean and peanut insect research in the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

A. Basic Biology, Physiology, and Nutrition

1. Soybean Insects. At Tifton, Ga., lesser cornstalk borer moths were caught in 15-watt black light walk-in type traps, and in larger numbers than indicated by previous reports. More females were taken than males and about one-third of the females were mated and contained eggs at the time of capture. A method was developed for inducing egg-laying by the moths taken in light traps, and eggs have been obtained in large numbers for use in various biological studies.

At Columbia, Mo., studies of the biology of the broad-headed bugs, Coriscus pilosulus and C. eurinus revealed these insects undergo five nymphal instars. The development period from egg to adult required about 30 days. Approximately another 20 days ensue from adulthood until the first eggs are laid. Large numbers of C. pilosulus and C. eurinus were found mating in old soybean stubble on June 15. Approximately 50% of the eggs collected in the fall of 1964 hatched on removal from refrigeration in March 1965.

B. Insecticidal Control

1. Lesser Cornstalk Borer. In 1964 at Tifton, Ga., insecticides were applied in granular form at rates of 1 and 1/2 pound per acre (except dieldrin, which was applied only at 2 pounds) over rows of seedling cowpeas in the 2-leaf stage of growth.

The insecticides used were dieldrin, trichlorfon, ethion, diazinon, fenthion, Bayer 25141, Union Carbide 10854, Bomyl, and triphenyltin hydroxide. The first five gave effective control of the insect.

Chemagro 25141, American Cyanimid 47031, Mobil MCA-600, and UpJohn-12927 were applied to soybean plants as sprays at 4, 8, and 16 ounces per acre. At intervals samples of the foliage were obtained from each plot, taken to the laboratory and fed to 4-day-old fall armyworm larvae. Chemagro 25141 treated plots were sampled at intervals up to 20 days and all rates gave good control during this period. The plots treated with AC 47031 were sampled at intervals up to 12 days. Control with the 16-ounce rate ranged from 60 to 100% through the 8th day, but was negligible on the 12th day. The 4 and 8 ounce rates gave poor control. Foliage from plots treated with MC-A-600 were sampled at intervals of 0, 1, 3, and 4 days. Control with the 4-ounce rate was 94% immediately after treatment, 33% for the 1-day sample, and negligible thereafter. The 8-ounce rate gave immediate control of 99% but dropped to 14% for the 3-day samples. The 16-ounce rate gave 100% immediate control, 98% at 1 day, 30% the 3rd day, and 20% the 4th day. The plants treated with U-12927 were sampled at intervals up to 21 days. The 4-ounce rate gave 100% immediate control, 88% after 1-day, and 44% or less after the 2nd day. The 8-ounce rate gave 96 to 100% control the first 2 days, 83% the 3rd day, and 56% or less after the 6th day. The 16-ounce rate gave 90 to 100% control through the 6th day, 70% through the 10th day, and 56% or less on the 13th day and later.

C. Insecticide Residues

1. Imidan. At Tifton, Ga., soybean plants were treated with sprays of Imidan at 4, 8, and 16 ounces per acre. Samples of the treated plants were taken as soon as the sprays had dried and at intervals of 1, 2, 4, 7, 14, and 21 days. The residues in ppm were: for the 4-ounce rate, 14.32, 0.95, 0.75, 0.36, 0.05, and 0.04, (21-day sample lost); the 8-ounce rate 20,60, 2.33, 1.09, 0.68, 0.16, 0.13, and 0.04; for the 16-ounce rate, 48,29, 4.66, 2.10, 1.41, 0.64, 0.42, and 0.16. The samples were anlyzed by the total phosphorous method.

2. Parathion on peanuts. At Tifton, Ga., granular parathion was applied to peanuts at 2 pounds per acre to control the southern corn rootworm. Analyses showed that there were no detectable residues of parathion present in the peanuts.

D. Varietal Evaluation for Insect Resistance

1. Soybean Insects. At Columbia, Mo., approximately 30 varieties which appeared to show some resistance to stinkbug were selected from 100 varieties of soybean plant introductions. The varieties were evaluated in a field cage, 12' x 6' x 60', which contained approximately one green stinkbug (Acrosternum hilare) per square foot. The longer maturing varieties were more heavily damaged but there was no significant resistance shown by any of the 30 varieties.

2. Peanut Insects. At Tifton, Ga., laboratory produced eggs of the lesser cornstalk borer are being used to infest 14 selected peanut varieties growing in the field in order to evaluate them for resistance to this insect.

E. Insect Vectors of Disease

1. Soybean yeast spot. Field and laboratory tests conducted at Columbia, Mo., demonstrated the capability of Euschistus tristigmus in transmitting yeast spot disease to soybeans. Cage and laboratory tests involving the broad-headed bug, Corsicus pilosulus demonstrated that this insect also transmitted yeast-spot disease. A total of seven species of hemiptera in two families has been shown to transmit this disease to soybeans in the field.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

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TILLAGE, PEST CONTROL TECHNIQUES AND EQUIPMENT HARVESTING, AND HANDLING OPERATIONS CROP PREPARATION AND FARM PROCESSING; AND USE OF ELECTROMAGNETIC AND ULTRASONIC ENERGY

Agricultural Engineering Research Division, ARS

Problem. Tillage of the soil is the greatest consumer of power in the production of crops in the United States today While some tillage is needed for nearly all crops, there is good evidence that much unneeded and in some cases detrimental tillage operations are performed. There is a need for expanded research to give more precise information on the interrelationship of tillage, soil physical conditions, and plant growth.

Many pests attack oilseeds and peanuts resulting in dollar losses to farmers each year. Plant diseases, weeds, insects and nematodes are examples Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. There is a need for improved methods of much greater efficiency for applying pesticides to plants and the soil.

Development of equipment and methods for efficiently harvesting and farm handling oilseeds and peanuts, with emphasis on the preservation of inherent qualities during these processes is needed. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory. While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of some crops, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled.

Development of better methods, techniques, and equipment for use on farms for the initial preparation for market or the processing of oilseeds and peanuts is needed to increase efficiency in the use of labor and equipment, preserve quality and prevent spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes before development progress can be continued. The underlying principles that pertain to the cleaning and drying of different crops, curing of peanuts, and sorting need to be determined. The methods for processing farm crops are largely dependent on production practices and dictated by future handling or storage requirements. Consequently, this requires interdisciplinary collaboration in the creating of a completely mechanized program of crop production.

Production of many crops is hampered by poor, slow, or nonuniform emergence of seedlings after the seed is planted. Some electrical treatments have been found to accelerate germination and seedling emergence. If emergence in the field can be speeded up and better uniformity obtained, weed control can be much more effective, with resulting increased efficiency in production of crops.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers and soil scientists engaged in both basic studies and the application of known principles to solve problems dealing with the relationships between soil-engaging equipment and soil reactions. Also, a program in pest control techniques and equipment includes weed control in soybeans involving about 1.0 professional man-year.

A continuing long-term program is conducted involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on oilseeds and peanut harvesting equipment and methods is cooperative with the experiment stations at Stillwater, Oklahoma (castor beans); Bogalusa, Louisiana (tung nut); and Holland, Virginia (peanuts). The Federal engineering effort devoted to research on oilseeds and peanuts harvesting and handling operations and equipment totals 3.6 professional man-years.

The Department's effort in the area of crop preparation and farm processing (except cotton) constitutes a long-term program involving agricultural engineers and statisticians engaged in both basic and applied research on the engineering phases of crop preparation and farm processing. Research on the processing on tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Mississippi Experiment Station and industry. Drying of castor seed is cooperative with the Oklahoma Experiment Station. The Federal engineering effort devoted to research in this area totals 0.7 professional man-years.

Studies on effects of electric glow-discharge radiation on seeds and plant products have been continued at Knoxville, Tennessee, in cooperation with the Departments of Agricultural Engineering, Agronomy, and Nutrition of the Tennessee Agricultural Experiment Station and the Crops Research Division, ARS.

PROGRAM OF STATE EXPERIMENT STATIONS

Many of the State agricultural experiment stations are engaged in both fundamental and applied research dealing with the development of new principles and the application of currently available knowledge to the problems concerned in soil-machine relationships in order to increase efficiency in crop production.

Both basic and applied research investigations which have been designed to discover and develop methods, techniques, and equipment for control of the many pests that attack our economic crops are in progress at the several agricultural experiment stations. Much of this work is cooperative with the Department.

These studies are involved in the complicated objectives of furthering the efficiency and the means for better control of insects, plant diseases, nematodes and weed problems through application of engineering knowledge on the use of aerial and ground chemical applicators for liquids and dusts, flame cultivators and mechanical devices for soil manipulation and soil fumigation.

Detailed investigations are in progress to develop reliable mechanical harvesting and handling equipment as well as ways in which improvements might be made in crop production systems to increase yields, product quality and overall efficiency.

Drying or curing investigations are in progress on forage crops, cereal crops including rice, feed grains including grain sorghums and soybeans, nuts, tobacco, peanuts and coffee. Closely associated with these studies are development and adaptation studies of flow systems, equipment and packages to move products without damage into and out of storages and to the market place.

Investigations in progress many of which are cooperative with the Department involve the evaluation of the use of radiofrequency energy for treatment of grains to destroy insect infestation and treatment of seeds to improve their germination characteristics.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Effect of Tillage Practices on Plant Growth. The effect of the crop preceding and the depth of seedbed preparation on peanut production, cooperative with Georgia, was continued. The area was prepared and planted to corn, cotton, soybeans, and winter rye grass. The results of these investigations from the last two years continued to indicate that the previous crop had greater influence on the yield than the tillage used.

B. Weed Control in Soybeans. Field studies were continued in Missouri to determine the effectiveness of 8, 10, 12, 14 and 16-inch band applications of amiben and NaPCP for weed control in soybeans. These studies were conducted in a manner similar to those in corn, but with the different chemicals Results were similar as no significant difference in soybean yield was noted for any of the band applications.

The direction of movement of the herbicides in soil was studied during the band applications in corn and soybeans in Missouri. In the crop year 1963, under dry soil conditions, weed control was effective over a wider area than the applied band. In 1964, control was limited to the actual area under the band. This would denote that there is greater lateral movement of the herbicide under dry soil conditions, however, this study will be continued in order to establish conclusive results.

Field studies were continued in cooperation with the Missouri Station to compare the effectiveness of 10, 6.6 and 3.3 percent concentrations of granular amiben (3 lbs./A) for weed control in soybeans. Applying more granules while maintaining the same acid equivalent application rate did not result in better weed control or increase soybean yields. In some cases, the higher concentrations, i.e., 10 and 6.6 percent, resulted in better weed control and soybean yields. More granules which result in a greater distribution per unit area did not increase weed control when amiben is applied under field conditions.

Initial field studies were made in Missouri to determine the effectiveness of depths of incorporation of two herbicides used for weed control in soybeans. Incorporation of amiben (1, 2, 3 and 6 lbs./A) and trifluralin (1 lb./A) to depths of 0-, 1/2- and 1-inch with a power rotary cultivator did not result in increased weed control or soybean yields. No combination of herbicide and incorporation depth resulted in any significant better weed control than when the herbicide was not incorporated.

Studies were also made in Missouri to determine if soil moisture had an effect on weed control when amiben (0 and 2 lbs./A) was incorporated for weed control in soybeans. No correlation between weed control and soil moisture was indicated by weed control regardless of incorporation.

Field studies were continued in Missouri to compare the effectiveness of four methods of shallow (above the seed) incorporations of three pre-emergence herbicides for weed control in soybeans. The rotary hoe, Atkins Phelps Mix-A-Product, power rotary cultivator and Gandy Ro-Wheel were used to incorporate amiben (1 and 2 lbs./A) and trifluralin (1 lb./A). In most cases the shallow incorporation gave less control of early grass over no incorporation and did not result in any significant increase in soybean yield or overall better weed control. Very erratic results occurred due to the difficulty in maintaining a uniform depth of incorporation for all equipment except the rotary hoe.

C. Oilseeds and Peanut Harvesting Equipment

1. Castor combine for harvesting damp or dry castor beans. Over 25 percent of the cost in production of castor beans is in harvesting and hauling (based on average yields and custom harvesting). Present machines require completely dry capsules for effective harvesting. Frequent adverse harvesting conditions result in small acreage per machine and large harvesting costs per acre. This cost can be reduced through development of a combine-type harvester which will operate effectively on damp or dry castor beans. Development of this type machine was continued this year. The addition of an aspirator-type cleaner as an integral part of the huller was effective in removing loose hulls. This produced a clean product in the bin with less cleaning load on the combine screens. Harvester components were designed to reduce field losses, amount of cracked and broken seed, and to gather the plants into the header without "chokes." Operating the harvester under widely varying crop conditions showed the need for further development for effective and efficient operation. Seed breakage was found to be excessive in the conveying system from the combine sieves to the storage bin. Data and information obtained should be valuable in further development of castor harvesters.

Development of moving brush row seals. Simplification of an attachment is needed for effectively gathering castor beans under widely varying crop conditions. The principle of using moving brushes on the combine header to act as conveyors for moving loose castor beans into the header (invented on this project) proved to have merits for further development. A new, more rugged, design, which will permit replacement of worn segments, needs to be incorporated for further development of the attachment.

2. Development of tung harvesters and windrowers. Tests showed the amount of tung left on the ground by hand labor was greater than with a mechanical harvester. In addition, the scarcity of dependable labor for hand harvesting and increasing labor costs each successive year is a problem facing the tung growers. Modifications made on the experimental harvester to move windrowed tung onto the elevating conveyor were shown to be effective under most field conditions. Improvements in use of air, at strategic locations, for separating large masses of leaves from tung fruit were effective on dry leaves but were not sufficient to remove all of the leaves when wet material was encountered.

Additional changes and tests are planned for improving the harvester to operate under a wider range of conditions. The use of wire-bound boxes of approximately 1,000 pound carrying capacity and transported with a tractor front end fork lift from harvester to highway transport trailers has proven to be effective and efficient in handling harvested fruit on the project for 3 consecutive years. Some 76 boxes using this principle of handling the harvested crop were in use this year by growers.

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Tung hullers. A commercial walnut huller using a concave wire brush and rotating cylinder was tested on tung fruit. This principle of hulling showed promise as an effective way in removing outer tung hulls without breaking the kernels. The huller had a maximum capacity of 3 tons per hour and was effective on fruit containing 30 to 40 percent moisture w.b. The huller was less effective on tung of lower moisture content. Further investigations using this huller along with development of separation equipment for removing loose hulls are planned.

3. Pruning of tung trees to facilitate the use of equipment in production and harvesting. Pruning the lower limbs of 7-year-old established trees to approximately 5 feet above the ground did not show a significant difference in yield than trees not trimmed during the first year. The experiment will be continued to determine whether yields may differ in subsequent years. Growth measurements were made of seedling trees which are headed at approximately 5 feet above the ground and for natural heading trees. This is a long-time experiment to determine the yield potentials of normal growth tung trees to high headed trees suitable for mechanical harvesting.

4. Peanut digger development. An elliptical wheel assembly installed on an experimental peanut digger aids in removal of soil from the peanuts. By using a longer conveyor and installing each elliptical wheel with its major axis at right angles to the adjoining wheel, the problems of vine wrapping were reduced. Other refinements are planned to improve the overall digger performance.

5. Specific gravity, size and grade relationship studies with Virginia 56R green harvested peanuts show that both immature and mature peanuts range in specific gravity from 0.62 to 0.98, and that a satisfactory separation of mature from immature nuts cannot be made based on this characteristic. About 60 percent of the foreign material, however, can be removed by pneumatic equipment. Seventy-seven percent of the immature peanuts were one-half inch or smaller in diameter, whereas 97 percent of the mature peanuts were one-half inch or larger in diameter. A separator consisting of two vibrating screens was designed on the basis of these results. Material riding the top screen, 7/16- x 4-inch slots, contained 95.5 percent of the better grade unshelled peanuts, 28 percent of the immature peanuts, 16 percent of the loose shelled kernels and 50 percent of the foreign material. Material

riding the second screen, 1/4- x 3-inch slots, contained about 62 percent of the immature peanuts, 70 percent of the loose shelled kernels, 37 percent of the foreign material and a small quantity of small, unshelled peanuts. The material passing this screen, unshelled immatures, foreign material and split kernels, could be discarded with little or no economic loss. The separation of high moisture immature peanuts and foreign material improves quality and reduces drying problems and should reduce the potential of A. flavus development. The cleaning studies will be emphasized.

D. Tung Nut Processing

1. Farm processing of tung nuts. Hauling and milling charges for tung nuts with moisture of 35 to 50 percent is costly to the grower. If stored, the moisture level should be reduced to prevent deterioration. Pilot drying tests using up to 100 c.f.m. of 150° F. air per square foot floor showed the drying zone of high moisture tung under these conditions was approximately 4 feet. Drying zone refers to that part of the tung in the bin in which drying is actually taking place at any time. Additional tests are planned to determine optimum drying conditions.

E. Drying Castor Seed

1. Resistance of hulled and unhulled castor beans to air flow. Conditioning of castor seed is needed when moisture is excessive to make the product acceptable to buyers as well as to prevent increased acid content and oil quality deterioration. Basic relationships of air flow rate, resistance to air flow, moisture of material, density of material, and depth of material, for data obtained previously, were analyzed by multiple regression. Exponentional equations were found to express the data adequately. These equations may be used as guidelines for designing driers and drying requirements for hulled as well as unhulled castor beans.

Equilibrium moisture of castor seed. Equilibrium moisture of castor seed at different temperatures and humidities is needed to know the limits for efficient forced drying. A preliminary study of castor seed exposed to several atmospheres of relative humidity at room temperature showed the seed to have the following moisture contents: Approximately 7.5 percent moisture (w.b.) (wet basis) when exposed to an atmosphere of 75 percent relative humidity; approximately 5.3 percent moisture (w.b.) when exposed to an atmosphere of 53 percent r.h.; approximately 4.4 percent moisture (w.b.) when exposed to an atmosphere of 37 percent r.h.

Drying requirements of high moisture unhulled castor beans. Unhulled castor beans containing high moisture cannot be hulled effectively. In addition, castor beans containing high moisture (above 6 percent w.b.) will result in oil quality deterioration when subjected to certain drying conditions.

Factors affecting the drying of castor beans (resistance of air flow, temperature and quantity of air density, depth and condition of castor beans) are needed to design effective driers. Drying studies were made using 120° F. temperature air at several rates on unhulled castor beans of different moisture contents, also using several bin depths and densities of material in bins. Unhulled castor beans of 30 percent w.b. moisture were found too wet for satisfactory drying. A depth of approximately 3 feet was found to be maximum when drying 14 percent w.b. moisture castor beans using 70 c.f.m. per square foot floor, 120° F. air at 3 percent r.h. Static pressure to air flow was reduced slightly as the material became dry while the drying air volume and temperature were kept constant. A guide to efficient drying would be to reduce the air volume or temperature or both when the air leaving the drying material does not contain a maximum of moisture.

F Use of Radiofrequency and Glow-discharge Equipment on Soybeans.

In cooperation with the University of Tennessee Department of Agronomy, Lee soybeans were planted in a field test. Three levels of treatment and a control were replicated six times in a randomized experiment. Time and pressure were held constant at 5 minutes and 3 mm Hg, respectively. Current levels were 20 ma, 40 ma, and 80 ma. No significant increases in early germination, total germination, and yield were caused by treatment. The test will be repeated in 1965 using different levels of current than used in 1964.

Results of analyses on oil from treated soybeans showed a trend for the oil from the treated beans to oxidize more rapidly than the control sample. there were large variations between replications, and the method used in extracting the oil was the suspected cause. A different method will be used for future experiments.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Oilseeds and Peanut Harvesting Equipment

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Drying Castor Seed

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

FLAXSEED
INDUSTRIAL UTILIZATION OF LINSEED OIL
Northern Utilization Research and Development Division, ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by widespread use of synthetic products derived from nonagricultural sources. Thus, over the years 1950-1960, use of linseed oil in drying oil products decreased from 590 to 351 million pounds because of displacement by synthetic materials capable of better performance. During the same period, consumption of synthetic products in protective coatings increased by 50 percent.

To restore the competitive position of linseed oil, new or expanded markets are urgently needed. Such markets can be achieved by an adequate program of basic and applied research. Recent studies by Department scientists have resulted in commercial manufacture and sale of linseed emulsion paints for exterior use that are competitive with synthetic resin emulsion paints. Expanding use of these new linseed oil paints is helping to maintain linseed oil in the market for exterior paints, which amounted to 70-75 million gallons in 1962. Another new product from linseed oil to which Department research is contributing is a protective coating for concrete that prevents deterioration from de-icers and freezing and thawing in winter. Additional research is needed to insure maximum acceptance and consumption of these new coatings and to provide still other new or improved products from linseed oil that can maintain and increase its use in all types of protective coatings, a market amounting to over 700 million gallons in 1964.

Other new outlets can be realized by chemical modification of linseed oil to obtain materials that will find applications in the multibillion-pound annual market for products of the organic chemical industry. To furnish a sound basis for chemical modification, a broad program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic research on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil total 17.8 professional man-years. Of this number 4.4 is devoted to industrial chemical products and 13.4 to protective coating products.

The current program at Peoria, Illinois, does not include research specifically devoted to chemical composition and physical properties of linseed oil.

Research at Peoria, Illinois, on industrial chemical products (4.4 professional man-years) involves exploratory studies to find new reactions and chemical derivatives and basic and applied research on cyclic fatty acids.

Studies on protective coating products in progress at Peoria, Illinois (10.4 professional man-years), include investigations on new resins and polymers from linseed oil for use as coatings and water-soluble vehicles, and basic research on problems related to development of linseed emulsion paints and to durability of linseed oil films. Research contracts on protective coating products (3.0 professional man-years) are in effect with Kansas State University, Manhattan, Kansas, for research on the use of linseed oil to protect concrete (.7 professional man-year) and on its use as a single coating for both curing and protection of concrete (.9 professional man-year); with North Dakota State University of Agriculture and Applied Science, Fargo, North Dakota, for investigations of aldehyde oils as components of protective coatings (.4 professional man-year); and with Stanford Research Institute, Menlo Park, California, for studies on properties and reactions of new vinyl copolymers of linseed oil (1.0 professional man-year).

The Department also sponsors research conducted by foreign institutions under grants of PL 480 funds. Research on industrial chemical products involves grants to the Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on stereospecific polymerization of polyunsaturated fatty esters (2 years, 1965-1967), and to the Regional Research Laboratory, Hyderabad, India, for exploratory research on hydroxylation reactions of linseed and safflower oils (5 years, 1963-1968). During the reporting period research was completed on minor constituents of linseed oil and thermal polymerization of polyunsaturated oils at the Experiment Station for the Fats and Oils Industry, Milan, Italy, and on organometallic compounds in protective coatings at the Paint Research Station, Teddington, England. These research topics were under the headings chemical composition and physical properties, industrial chemical products, and protective coating products, respectively.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations did not report research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Minor constituents of linseed oil. At the Experiment Station for the Fats and Oils Industry, Milan, Italy, a C_{20} terpene alcohol, structurally similar to farnesol, has been isolated from linseed oil and identified as

geranyl-geraniol. This material had not been isolated from natural sources previously but had been postulated as an important intermediate in the biosynthesis of di- and tetraterpenes. Measurement of the effects of minor constituents on the spraying and wetting properties of linseed oil has proven to be very difficult because of the lack of a physical method sufficiently sensitive to show the small differences involved. Contact angle measurements appear to offer the most promise to date. Experimental work on this PL 480 project has been completed but the final report has not yet been received.

B. Industrial Chemical Products

1. Cyclic acids. All alkyl esters of C_{18} hydrogenated cyclic acids (HCal) that have been studied passed the oxidative stability requirement of specification MIL-L-7808 for jet lubricant base stocks. Further studies of a number of HCal diesters to determine their suitability as jet lubricants under the new and more rigorous specification MIL-L-23699 indicated that satisfactory viscosity index, pour point and low-temperature viscosity could be achieved by blending one of the diesters with a commercial low-viscosity oil (Herclube C). The mixtures did not, however, meet oxidative stability requirements when formulated with an available amine-type inhibitor.

Industrial reports indicate, however, that selection of an oxidation inhibitor and other components of the "additive package" required to impart satisfactory properties to a synthetic ester lubricant is a very critical and highly specific operation. It is well known that an "additive package" giving excellent results with one lubricant may be completely ineffective with another. In view of these facts, the results with HCal diesters are considered very encouraging, although it will probably be necessary to enlist the cooperation of an experienced industrial formulator of synthetic lubricants to develop an adequate "additive package."

In engineering research on hydrogenation of cyclic fatty acids, the use of adequate palladium catalyst (0.25 percent or higher) was found to be the most important factor in complete elimination (by reduction) of aromatic components that prevent achievement of maximum high temperature oxidative stability. Pilot-plant tests indicated that extractive distillation of monomeric fatty acids from the cyclization reaction could be a useful low-cost method for partial purification of cyclic acids. (In extractive distillation, methyl esters of polymeric fatty acids are added to the charge to be distilled.)

Chlorotrifluoroethylene and 1,1-dichloro-2,2-difluoroethylene reacted with a variety of C_{18} conjugated dienoic ester materials to give cyclo-addition products in yields as high as 80 percent. These reactions appear to be promising routes to products that should have unique properties.

2. Glyceride polymers. Under a PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, studies on the ozonolysis of the dimer and trimer acids from heat polymerized linseed oil were continued.

Formaldehyde and propionaldehyde were the major products from the neutral fraction. Since these aldehydes were obtained in almost equal amounts, bond migration toward the terminal methyl group is indicated. Studies on the dibasic acids formed showed that essentially 50 percent of the double bonds nearest the carboxyl group remain in the original position. Experimental work on this project has been completed, but the final report has not yet been received. The grant is being replaced by a new one providing for studies on the stereo-specific polymerization of polyunsaturated fatty esters.

3. Hydroxylation of linseed oil. Two routes have been examined for introduction of single hydroxyl groups: sulfation followed by hydrolysis and epoxidation followed by reductive ring opening. The sulfation route was successful with methyl oleate and peanut oil, but not with polyunsaturated esters and oils. Formation of inner ethers may have interfered with the desired reaction. The epoxide route has not yet proved satisfactory because hydrogenation either failed to open the epoxide ring or yielded undesired products. This research is being conducted under a PL 480 grant to the Regional Research Laboratory, Hyderabad, India.

C. Protective Coating Products

1. Emulsion paints. Research on pigment interactions in water systems showed previously that attraction and flocculation of particles of two pigments occur at pH's between the isoelectric points of the pigments. Current results have revealed that particle size ratio of the interacting pigments determines the compositions of maximum and minimum mutual flocculation. Improved correction equations for vertical and horizontal interactions between particles have been developed that make possible greatly increased accuracy in the use of the Coulter counter. New equipment has been designed to permit precision control of variables in the study of factors affecting emulsification of linseed oil.

The new information on pigment interactions has provided an important advance in our understanding of the behavior of aqueous pigment suspensions. In particular, it has explained one of the more troublesome problems--unstable viscosity--encountered in development of acceptable linseed emulsion paints.

Three industrial companies are now marketing linseed oil emulsions for use in formulating paints. One of these companies alone is supplying some 150 paint manufacturers with linseed oil emulsion.

2. Linseed coatings for concrete. At Kansas State University, contract research on concrete specimens made with a sound quartz aggregate continues to indicate that air-entrained concrete can benefit from a linseed oil protective coating. Troweled surfaces were found to deteriorate more severely than formed surfaces, and reinforced beams more than plain beams. Application of a second coat after about a year of exposure would appear

advisable in practice to obtain best protection. Initial work at Kansas State on linseed oil coatings for simultaneous curing and protection of concrete is providing evidence that the surface "skin" of finished concrete is relatively weak and friable. Removal of this "skin" before applying linseed oil results in better protection to freezing and thawing. Unusual opportunities have arisen to test linseed emulsions under practical conditions of use for protection of concrete. With cooperation of the Chicago Park Board, special emulsions designed for low-temperature work were successfully applied at 36° F. to selected areas of the floor of the Grant Park underground garage. Arrangements have also been made for other practical tests of linseed emulsion concrete coatings in parking ramps and roads in Peoria, Illinois, and Washington, D. C.

3. New resins from linseed oil for use in water-soluble and other coatings. New types of potentially water-soluble vehicles were prepared by reacting various amounts of linseed alcohols with poly(maleic anhydride). A product containing 0.2 mole of linseed alcohols per maleic anhydride unit could be solubilized in water, but films were water-sensitive. Xylene solutions of a product containing 60 percent of linseed alcohols gave films having excellent air-drying properties and resistance to water, alkali and xylene. A resin comprising one mole of tris-(hydroxymethyl)aminomethane, two moles of linseed fatty acids and two moles of itaconic acid, solubilized as the dimethyl aminoethanol salt in aqueous isopropanol, gave rapid drying, water-resistant films. Films from a similar resin made with only one mole of linseed fatty acids dried slowly and lacked water resistance.

A series of new and promising film-forming resins was prepared by reaction of linseed dihydroxyamide with eight dibasic acids or anhydrides. Another type of polymer was prepared by condensation of 2-aminoethyl mercaptan with the half ester of maleic acid and linseed alcohols. This product gave tough but dark films when baked 15 minutes at 200° C. Linseed oil and hydrogen sulfide in methylene chloride solution were reacted at -69° C. by irradiation with ultraviolet light. Baked films from the treated oil (100° C.; 2 hrs.) had a hardness of 8 as contrasted with a hardness of only 2 for untreated linseed oil films baked under the same conditions.

These studies have resulted in availability of a variety of new products meriting further investigation. Those products that are sulfur derivatives are of particular interest because the mechanism by which their films dry or crosslink may result in formation of more stable bonds than are formed in drying of conventional products.

At North Dakota State University, reaction products of linseed monoaldehyde oil with maleic anhydride, polyvinyl alcohol or hydroxyethyl methacrylate gave films superior to those of linseed oil. Acetals of linseed monoaldehyde oil and polyols such as trimethylolpropane or pentaerythritol could be converted to urethane oils showing equal or better film properties than conventional urethane oils. In particular, these new urethane oils gave superior gloss and displayed greater ability to bridge the grain in heavily

grained wood such as mahogany. Because of their promising performance, it is planned to concentrate effort on these new coatings during the remainder of this contract research.

Initial studies on copolymers at Stanford Research Institute involved preparation of model triene compounds and preliminary copolymerizations of methyl linoleate or linolenate with ethyl acrylate, primarily to evaluate NMR for analysis of copolymers. In subsequent experiments, reactivity ratios for the copolymerization of ethyl acrylate or acrylonitrile with conjugated methyl linoleate were determined. The results indicated that it may be possible to prepare alternating copolymers.

4. Organometallic compounds in paints. Research under a PL 480 grant to the Paint Research Station, Teddington, England, has made considerable further progress, particularly in the development of gallate- and other polyhydric-phenol-modified coatings. The most promising vehicle, in terms of producing (without baking) a hard, adherent, anticorrosive coating on mild steel, was a gallate-modified, linseed-tung alkyd resin. Formation of these coatings involves direct complexing of phenolic groups in the vehicle with metallic iron in the substrate. "Soluble iron," particularly iron butoxide, was very effective in improving uniformity of the coatings. Adducts of vinyl phosphonic acid and conjugated fatty oils showed promise as antiflotation agents for certain pigments such as phthalo cyanine blue. Applications for additional public service patents have been filed to cover new developments during the past year. Laboratory work on this project has been completed, but the final report has not yet been received.

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SOYBEANS
FOOD AND INDUSTRIAL USES FOR SOYBEAN OIL
Northern Utilization Research and Development Division, ARS

Problem. Soybean oil is now the major edible oil of the United States and the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil both domestically and in foreign markets. It is estimated that in 1964 about 4 billion pounds of soybean oil (about 90 percent of total domestic use) was consumed in edible products, of which about two-thirds was consumed in hydrogenated form as margarine and shortening. However, production of soybeans has increased rapidly, amounting to almost 700 million bushels in 1964.

The most promising outlets for oil from this ever-growing production of soybeans appear to be in foreign markets as edible oils and fats and in domestic industrial uses. The potential market for vegetable oils imported by Europe is estimated at over 7 billion pounds by 1966. For soybean oil to capture a growing share of this market, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value, to determine the extent to which minor constituents influence flavor and other properties of the oil, and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. This information would also serve as the basis for improving soybean oil for domestic use both as a liquid oil and in its hydrogenated forms. Some additional consumption in the United States might be anticipated because of extended utility resulting from these improvements, even though consumption of edible fats and oils mainly increases with population growth. To achieve the objective, a broad program of basic and applied research is required to provide more knowledge of the properties of linolenic acid and of minor constituents of soybean oil; of the changes that take place in these and other components during oxidation, hydrogenation, and heating; of the effects of these changes on flavor, nutritive value, stability, and other qualities of the oil; and of the effects of modification of glyceride structure on functional properties of hydrogenated forms of soybean oil.

As an industrial oil, soybean, like linseed oil, is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. The best opportunity for increasing industrial applications of soybean oil appears, therefore, to be development of products that retain the glyceride structure of the oil. Thus, aldehyde oils, a recent discovery of Department scientists, appear to have a promising future, if current research and development is successful, in the multibillion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the potential industrial value of aldehyde oils and

other soybean glyceride products, more fundamental information is needed on reactions of soybean oil that will preserve the glyceride structure and on the physical and chemical properties of the products. Upon this basis, development of a wide variety of new, industrially useful products should be possible.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic and applied research on edible and industrial uses of soybean oil. A food technologist is also required by the program in connection with organoleptic evaluation of edible oils. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal and organoleptic stability. Objectives of research on industrial utilization are to obtain new information on reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries.

The Federal scientific effort for research on soybean oil totals 35.7 professional man-years. Of this number 7.1 are devoted to chemical composition and physical properties, 15.4 to edible utilization, and 13.2 to industrial utilization.

Research at Peoria, Illinois, on chemical composition and physical properties (7.1 professional man-years) is concerned with isolation and identification of components affecting flavor, heat, light, and storage stability of soybean oil and its hydrogenated products and with development of new and improved methods of separation and analysis for use in these studies. During the reporting period research was initiated with the specific objective of utilizing mass spectroscopy as a tool for solving difficult problems of analysis and characterization.

Research at Peoria, Illinois, on edible utilization of soybean oil (12.5 professional man-years) emphasizes basic and applied studies on selective hydrogenation as a means of stabilizing soybean oil by removal of linolenate. Research contracts (2.9 professional man-years) are in effect at IIT Research Institute, Chicago, Illinois, for development of heterogeneous selective hydrogenation catalysts (1.4 professional man-years); at Rutgers, The State University, New Brunswick, New Jersey, for basic studies on heterogeneous catalysts (1.0 professional man-year); and at the University of Illinois, Urbana, Illinois, for basic research on homogeneous catalysts (.5 professional man-year).

Research at Peoria, Illinois, on industrial utilization of soybean oil (9.0 professional man-years) involves exploratory studies to find new

reactions and products and basic and applied investigations of aldehyde oils and other aldehydic products. Research contracts (4.2 professional man-years) are in effect with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils (1.7 professional man-years) and with Archer Daniels Midland Company, Minneapolis, Minnesota, for pilot preparation of various aldehyde oil products needed for developmental investigations (2.5 professional man-years).

The Department also sponsors research on soybean oil conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to Gdansk Polytechnic, Gdansk, Poland, for studies on soybean sterols and their effect on stability of the oil (4 years, 1961-1965). During the reporting period research was completed on removal of trace metals from soybean oil with ion exchange resins at the Institute for Fats and Their Derivatives, Seville, Spain. Research on edible utilization is conducted under grants to the University of Granada, Granada, Spain, for studies on the effect of processing on frying quality of soybean oil (5 years, 1962-1967); Toyo University, Kawagoe, Saitama-ken, Japan, for research on hydrogenation of soybean oil (5 years, 1962-1967); Sugiyama Chemical Research Institute, Tokyo, Japan, for basic studies on the color reversion of soybean oil (2 years, 1964-1966); and Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on certain metal chelate compounds as catalysts for selective hydrogenation of soybean oil (2 years, 1965-1967). Research on industrial utilization involves grants to Queen Mary College, University of London, London, England, for basic studies on alkaline cleavage of polyunsaturated fatty acids (5 years, 1961-1966); and the Experiment Station for the Fats and Oils Industry, Milan, Italy, for research on oxidation with atmospheric oxygen to obtain new soybean oil derivatives (5 years, 1961-1966). During the reporting period research was completed on separation of mixtures of fatty acids at the University of Helsinki, Helsinki, Finland.

PROGRAM OF STATE EXPERIMENT STATIONS

Station research on food and industrial utilization of soybean oil involves study of the chemical, physical, and nutritional properties of the oil. Investigations directed to isolation, fractionation, and chemical identification of the compounds responsible for the reversion flavor of soybean oil continue. The mechanism concerned with flavor reversion is being studied. Content of non-carbonyl and carbonyl compounds in stable cottonseed oil is being compared with reverted soybean oil in the search for clues to explain the flavor reversion and to provide practical methods for preventing or retarding its formation.

Oilseed processing conditions and methods of extraction and recovery of oil from oil-bearing seeds are under investigation. Other research involves fundamental studies on the enzymatic formation of fats and oils in plants,

antioxidant mode of action, and the isolation of sulfur-containing lipids and glycolipids in plant tissues.

The total State effort devoted to soybean oil utilization is about 4.8 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Mass spectroscopy investigations. Studies have been undertaken to maximize the effectiveness of mass spectroscopic techniques for characterizing fatty acids and their chemical conversion products. Research on selective hydrogenation and other approaches to improvement of soybean oil as an edible oil, as well as research on converting soybean oil to new industrial products, present formidable problems in precise identification of products formed. By investigation of the explicit application of mass spectroscopy to these problems, the maximum capability of this powerful research tool should be realized.

In initial studies with model compounds, mass spectra were determined for methyl and ethyl sorbates, four methyl hexenoate isomers, ethyl 2- and ethyl 3-hexenoates, methyl 2-octenoates, and some of their deuterated derivatives in conjunction with mechanism studies of the catalytic hydrogenation of methyl sorbate in the presence of pentacyanocobaltate II ion. Mass spectrometric analysis of the hydrogenation product, methyl 2-hexenoate, using deuterium as a tracer, showed that the added hydrogen came from the water solution rather than from the gas phase. Three deuterium atoms were found rather than the expected two when the hydrogenation was performed in heavy water indicating that the third deuterium was added by exchange.

2. Components of autoxidized soybean oil. A new gas-solid chromatographic method of exceptional resolving power has been developed for analysis of volatile hydrocarbons found in autoxidized fats. Mixtures of C_1 to C_{10} paraffins and olefins are separated from each other, from acetylene, and from several cyclic hydrocarbons in less than 40 minutes.

This new technique has promise of providing a unique procedure for "fingerprinting" various vegetable oils and derived hydrogenated products. Hydrocarbon formation is among the first detectable signs of autoxidation; hence, the method may prove capable of providing an exceptionally sensitive indication of the previous history of a sample, as well as information pointing to its identity. Besides its value to research, the procedure obviously has potential for commercial use; e.g., for establishing specifications and verifying adherence to standards.

3. Removal of prooxidant metals. In studies under a PL 480 grant at the Institute for Fats and Oils and Their Derivatives, Seville, Spain, demetalization of soybean oil with macroreticular exchange resins was evaluated in

detail. Oils were passed through the resin columns, analyzed for metal content before and after treatment, and treated by the usual alkali-refining, bleaching and deodorization processes but with the addition of antioxidants and inactivators. Statistical analysis of the data indicates that the flavor stability was significantly improved by the procedures described. Laboratory work has been completed, but the final report has not yet been received.

4. Effects of sterols on flavor stability. Sterols of soybean oil were found to undergo highly complex transformations during alkali-refining and bleaching. Alkali and oxygen adsorbed in the bleaching earths play an important role in inducing these changes. Bleaching appeared to effectively remove apolar steroids from the oil. This research is being conducted under a PL 480 grant at Gdansk Polytechnic, Gdansk, Poland.

B. Edible Utilization

1. Selective hydrogenation. Studies on homogeneous catalytic hydrogenation with pentacyanocobaltate II showed that hydrogenation occurred only when the substrate could coordinate with the catalyst. Thus, only higher fatty acids containing triple conjugation and a trans bond could be hydrogenated.

Mixtures of copper and chromium salts reduced with sodium borohydride yielded extremely selective (selectivity ratio = 7) catalysts in small-scale (1 gm.) hydrogenations of soybean oil. Attempts to use these catalysts for hydrogenation of 2-liter samples of oil have so far provided selectivity ratios of only 2.5. In the presence of dimethyl formamide (DMF) 81-percent yields of monoene with concomitant 13.4-percent yields of stearate were obtained with palladium-carbon catalysts as compared to 45 percent and 35.7 percent, respectively, without DMF. The product prepared in DMF, when ozonized, yielded 73 percent of C_9 and C_{12} dibasic acids compared to 46 percent without DMF. This observation shows that there was less wandering of the double bonds when DMF was present.

Nickel (III), cobalt (III), copper (II) and iron (III) acetylacetonates, when used as catalysts for hydrogenation of soybean and linseed methyl esters, showed high selectivity toward linolenate (selectivity ratios of 3.5-4.1). These reactions were conducted in methanol solution. However, attempts to hydrogenate soybean oil with nickel (III) acetylacetonate under these conditions resulted in conversion of the triglycerides to methyl esters. Alcoholysis was avoided by changing the solvent but the catalyst was at best only slightly active under these conditions.

Iron pentacarbonyl was shown to be an effective conjugation reagent, making possible the production of oils in which 93 to 97 percent of the poly-unsaturated acids were conjugated, mainly in the all-trans-configuration. The method has been applied to soybean, linseed and safflower oils.

During investigation of extractive rearrangement of soybean oil, it was discovered that certain solvents enhance the selectivity of hydrogenation catalysts. Thus, when a mixture of linseed and safflower oils was hydrogenated in dimethyl formamide, the selectivity ratio for the catalyst increased from 1.8 to 4. Other solvents that behave similarly include furfural, acetonitrile, tetramethyl urea and trimethyl phosphate. By use of an analog computer it can be shown that when the selectivity ratio is of the order of 4.0 it is possible to hydrogenate soybean oil selectivity to less than 2 percent linolenic acid without necessitating winterization to remove excessively hardened oil. The results achieved during the year show that selectivity ratios of 4 or more can be obtained by laboratory procedures. Considerable further study will be needed to determine if industrially feasible processes of equivalent effectiveness can be developed.

In the contract research program, scientists at the University of Illinois discovered that stannous chloride markedly changes the selectivity of hydrogenations catalyzed by platinum-triphenyl phosphine complexes. Thus, soybean esters could be selectively hydrogenated to trans monoenes without forming saturates. Several new palladium complexes also proved to be highly effective catalysts.

At IIT Research Institute comparative experiments with Linde Type X molecular sieves impregnated with nickel and with rhodium showed no consistent preference for attack at the 15,16 bond of linolenate. The rhodium catalysts produced much more trans bonds than did the nickel catalysts. The nickel catalysts made with X-type sieves were 10 to 20 times more active than similar catalysts made with A-type sieves. In the research at Rutgers, the principal achievements were improvement of resolution of infrared emission spectra for oleic acid and development of an effective stirring device for microhydrogenation.

2. Hydrogenated-winterized soybean oil. Study of acetone-oil mixtures used in preparation of hydrogenated-winterized soybean oil showed that phase separations could be easily achieved by adjustment of temperature or by addition of 3 to 8 percent of water. In producing hydrogenated-winterized soybean oils, proper use of phase separation techniques could eliminate distillation costs, minimize solvent losses and provide a basis for development of a continuous solvent winterization process.

3. Frying quality of soybean oil. In studies under a PL 480 grant at the University of Granada, Granada, Spain, tests conducted in a professional school for country people who were habitual consumers of olive oil showed they were unable to identify whether olive oil or soybean oil had been used in the preparation of their usual meals. These results were the same as those found when two university groups (men and women) were tested.

4. Partial hydrogenation of soybean oil. Studies with copper-nickel catalysts have progressed to preparations of approximately 4 kg. of hydrogenated-winterized soybean oil with linolenate contents of 5 to 6 percent.

Stability was apparently improved when metallic impurities that result from the use of copper-nickel catalyst were inactivated. Reuse of the catalyst showed appreciable loss in activity after five repeated runs, whereas nickel catalyst in the United States is frequently used much longer. Longevity of catalyst activity appeared to be associated with nickel content. A 9.5:1:10 (copper:nickel:kieselguhr) catalyst had a longer life than a 9.5:0.5:10 catalyst. This research is being conducted under a PL 480 grant at Toyo University, Kawagoe, Saitama-ken, Japan.

C. Industrial Utilization

1. Oxidative cleavage of soybean oil and its fatty acids. Further study of solvent systems for ozonization showed that nearly quantitative conversion of double bond to aldehydic products was achieved with mixtures of acetic or propionic acid and ethanol, n-propanol or isopropanol. A 1-butanol-propionic acid system (aldehyde yields over 90 percent of theory from pure methyl oleate) appeared promising for industrial use. As another approach, soybean oil methyl esters were mechanically emulsified in water and ozonized. Subsequent yields of aldehyde were 86 percent of theory by chemical reduction or 81 percent by hydrogenation. An economic analysis is now needed to decide between inexpensive aqueous systems, which give lower yields of product, and the more expensive organic solvents, which give high yields. It is anticipated that this type of evaluation will be made under the recently initiated contract project at Archer Daniels Midland Company, which provides for developmental studies on aldehyde oils.

2. Aldehyde oil derivatives. By use of optimal time, temperature and pressure and of a nonpolar solvent to repress amonolysis of the ester group, methyl and butyl azelaaldehydates have been converted to the 9-amino esters in yields of 92 and 93 percent, respectively. Solvents such as heptane and decalin were found to be nearly as satisfactory as methyl cyclohexane for use in reductive amination of methyl azelaaldehydate (MAZ). The C_3 analog of the MAZ pentaerythritol acetate was synthesized and polyesterified with ethylene glycol. The polymer was lower melting and less soluble in common solvents than the corresponding MAZ poly(ester-acetal).

At Fabric Research Laboratories, poly(ester-acetals) were prepared from the glycerol (I) and 2-hydroxymethyl-2-methyl-1,3-propanediol (II) acetals of MAZ. A study of esterification catalysts showed that lead acetate trihydrate effectively promoted, at temperatures below 250° C., ester interchange in the polymer from I without causing acetal interchange. The polymer from II crosslinked under these conditions.

3. Separation of fatty acids. In final phases of research under a PL 480 grant to the University of Helsinki, Helsinki, Finland, crystallization methods were developed to separate polyunsaturated fatty-acid concentrates from soybean and linseed fatty acids in over 90 percent purity and in satisfactory yields. Liquid-liquid extraction of the soybean concentrate gave linoleic acid in over 91 percent purity, and linolenic acid in over

98 percent purity was obtained from the linseed concentrate. The combined crystallization-extraction process should be an improvement over liquid-liquid extraction for economical production of high purity linoleic and linolenic acids.

4. New derivatives. Basic information on the reactions that occur when fatty acids are fused with alkali has been obtained with reactions involving potassium deuteroxide. Deuterium replaced hydrogen on carbons 2 through 5 but did not replace hydrogen on carbons 12, 13 or 14 in myristic acid. Myristic acid gave small amounts of lauric acid, and it is presumed this reaction occurred by dehydrogenation followed by the Varrentrapp reaction. Studies with saturated and aromatic acids indicated that little if any attack in this reaction occurred at carbon 3. Alkali fusion with sodamide gave high yields of saturated hydrocarbons of one less carbon atom. Substitution in the 2 and 4 positions stabilized the saturated acids to alkali fusion but substitution in the 3 position was much less effective. These studies are in progress under a PL 480 grant to Queen Mary College, University of London, London, England.

At the Experiment Station for the Fats and Oils Industry, Milan, Italy, research under a PL 480 grant has been directed toward testing various metal chelates with a variety of ligands for their effect on rate of autoxidation of methyl oleate. This work has involved the preparation and purification of metal chelates of individual fatty acids. Not only has the rate of catalytic autoxidation been studied but information has also been gained on the decomposition of the formed hydroperoxides. The data are being used to correlate stability constants of chelates with their infrared structures, with the view of developing theories to explain the differences in catalytic activity observed.

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SOYBEANS
FEED, FOOD AND INDUSTRIAL USES FOR MEAL AND PROTEIN
Northern Utilization Research and Development Division, ARS

Problem. Production of soybeans has increased rapidly to almost 700 million bushels in 1964. For profitable disposition, now and in the future, of the growing supplies of meal from U. S. soybeans, improved feed products and new food and industrial uses are needed. Europe is developing a mixed-feed industry that needs high-protein concentrates. This market could approach that in the U. S. which uses high-protein meal from 400 million bushels of soybeans. For U. S. soybeans to achieve the maximum share of this market, more fundamental information is needed on the proteins and other nutritionally important constituents of soybeans and on the effects of processing on these components. Such information should make possible the production of feeds from soybeans having maximum feeding value that would meet the requirements of foreign markets as well as help maintain or increase the use of soybean feeds in the U. S.

U. S. soybeans could play a dominant role in alleviating the world shortage of dietary protein if more information were available on utilizing soybeans and soybean meal, flour, protein and protein concentrates in food products tailored to meet the nutritional and palatability requirements of foreign markets. That the possibilities are very real for increased utilization of soybeans in foreign food is indicated by recent work of the Department that showed how to use U. S. soybeans for Japanese foods. The result of this work was that a market for selected soybeans for Japan was opened that now exceeds one million bushels per year. If U. S. soybeans are to achieve the maximum share of foreign food markets, basic information on nutritionally important components and effects of processing on these components will be needed. In addition, better knowledge will be required of how to use soybean protein products in foodstuffs that will be acceptable abroad.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program involving organic and physical chemists and biochemists engaged in basic research on the characterization of components of soybean meal and protein and application of the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein.

The Federal scientific effort on utilization of soybeans and soybean meal and protein totals 14.5 professional man-years. Of this number 7.1 are devoted to chemical composition and physical properties and 7.4 to food products.

Research at Peoria, Illinois, on chemical composition and physical properties (7.1 professional man-years) involves basic studies on isolation and

characterization of components of whey proteins and on heat gelation of alcohol-washed protein.

Research at Peoria, Illinois, on food products (7.0 professional man-years) is devoted to development of information on specially processed soybean products pertinent to their use in high-protein foods for foreign markets. One segment of this research--engineering studies on conversion of soybeans to high-quality, full-fat flours--is supported by the Agency for International Development. A research contract (.4 professional man-year) at the University of Illinois, Urbana, Illinois, is concerned with investigation of factors possibly present in soybeans that could cause digestive disturbances.

The current program at Peoria, Illinois, does not include research specifically directed to industrial or feed products.

The Department also sponsors research on utilization of soybeans conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the University of Edinburgh, Edinburgh, Scotland, for investigations on polysaccharides of soybeans (5 years, 1961-1966); to the Weizmann Institute of Science, Rehovot, Israel, for research on complexes between soybean protein and other components of the meal (5 years, 1961-1966); to Kagawa University, Takamatsu, Japan, for a chromatographic study of soybean sugars and oligosaccharides (3 years, 1963-1966); and to the University of Tokyo, Tokyo, Japan, for studies on soybean sterols in defatted meal (4 years, 1963-1967).

Research on food products involves grants to the Central Miso Institute, Tokyo, Japan, for studies on miso made from dehulled soybean grits (4 years, 1962-1966); Bar-Ilan University, Ramat Gan, Israel, for studies on miso-type food products for use in Israel (3 years, 1962-1965); Israel Institute of Technology, Haifa, Israel, for evaluation of the quality of isolated soybean protein for use in Israeli foods (4 years, 1962-1966); Japan Tofu Association, Tokyo, Japan, for studies on the use of U. S. soybeans for making tofu (4 years, 1963-1967); Institute of Chemistry, Academia Sinica, Taipei, Taiwan, for investigation on preparing Chinese cheese from soybeans (5 years, 1963-1968); Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan, for studies on improved strains of Saccharomyces rouxii for making shoyu and miso (5 years, 1963-1968); and University of Tokyo, Tokyo, Japan, for investigations on the flavor components of enzymatically or chemically modified soybean meal and proteins (3 years, 1964-1967).

Research on feed products involves a grant to the Hebrew University, Rehovot, Israel, for basic studies on soybean saponins (5 years, 1961-1966).

PROGRAM OF STATE EXPERIMENT STATIONS

The current station program involves both basic and applied research on soybean protein and meal utilization. Much of the basic research is aimed

at characterization of soybean meal and protein. Application of this information to utilization is also made through several studies involving feed use of the meal. Basic studies seek to characterize the proteins and identify such biologically active components as proteolytic enzymes and their inhibitors. Other work is being directed to separation and identification of the proteins in soybean whey. Genetic effects as expressed in different varieties are being observed. Peptide structure of the individual purified proteins is investigated. Other researches involve study of the basic mechanisms of the biosynthesis of proteins.

In the area of food use, production of high protein fermented foods such as tempeh from soybeans is the subject of a pilot study. This involves methods of processing, fractionating or modifying soybeans to produce low-cost, protein-rich foods of value for feeding infants and children.

Extensive economic feasibility studies are in progress. These range from use of meals in livestock feeds to the impact of the common market.

Total research effort devoted to soybean meal utilization is 5.8 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Basic studies on soybean protein. Insolubility of isoelectrically precipitated protein has been shown to be caused in part by disulfide bonding affecting the 7S and 11S components. The 2S and 7S fractions also are involved in formation of insoluble material apparently by a mechanism not involving disulfide bonding, since mercaptoethanol did not solubilize such material. Analysis of a number of soybean protein fractions for their carbohydrate content revealed that the proportion of carbohydrate in 7S protein is 17 times as great as in 11S protein. The present results provide additional evidence that the 11S and 7S fractions are not merely aggregates or polymers of identical subunits.

Gel electrophoresis has proven very effective for characterization of soybean proteins. Whey proteins were resolved into 18 bands. The four trypsin inhibitors isolated at the Northern Division and reported last year were found to be heterogeneous; for example, inhibitor A_2 showed six or more minor bands.

Other studies showed that trypsin inhibitors account for 30 to 50 percent of the growth inhibitory activity of raw meal and for nearly all of the pancreatic hypertrophic effect. The trypsin-trypsin inhibitor reaction was shown to involve cleavage of a sensitive bond in the inhibitor. These findings provide basic information important in development of soybean foods and feeds having optimum nutritive value.

2. Soybean sugars, oligosaccharides and polysaccharides. Under a PL 480 grant at the University of Edinburgh, Edinburgh, Scotland, studies showed that hydrolysis of soybean cotyledon polysaccharides gave the following monosaccharides: galactose, galacturonic acid, arabinose, xylose, fucose, rhamnose, glucose, mannose, and aldobiouronic acid. The results indicate that these polysaccharides are a mixture of a neutral arabinogalactan and an acidic pectin-type complex, with structural features similar to gum tragacanth. The acidic polysaccharide fraction is the major one.

In other PL 480 research at Kagawa University, Takamatsu, Japan, quantitative analyses of the sugars in U. S. and Japanese soybean varieties appear near completion. Preliminary studies have shown an increase in reducing sugars when soybean meal is autoclaved. However, the amounts of some individual sugars increased, whereas decreases were observed for others.

3. Complexes of soybean protein with other meal constituents. Scientists at the Weizmann Institute of Science, Rehovot, Israel, have isolated a glycopeptide from soybean hemagglutinin, thereby establishing the glycoprotein nature of this protein. This work is being conducted under a PL 480 grant.

4. Soybean sterols. Under a PL 480 grant at the University of Tokyo, Tokyo, Japan, scientists developed a method for extracting the sterols from soybeans and for analyzing them on a chromatographic column. Application of this method has revealed the presence of an unknown sterol fraction tentatively identified as an esterified sterol glycoside.

B. Food Products

1. Flavor and nutritive value of soybean food products. An intensely bitter fraction was isolated from soybeans. Nine components were found in this fraction, of which a phenolic acid (ferulic acid) and two isoflavone aglycones (genistein and daidzein) were identified. Saponins crystallized from alcohol extracts of soybeans did not have a bitter taste. Presence of a leucoanthocyanin in soybean meal was confirmed. The indication that bitterness in soybeans is not caused by saponins but may instead be due to phenolic acids, flavenoids and/or unidentified components is an interesting lead that represents a departure from previous concepts. In peanuts, for example, bitterness has been attributed to saponins.

Studies at the University of Illinois showed that low-molecular-weight constituents of soybean whey solids and of the 80-percent ethanol extractives of soybean meal are the primary cause of flatus in humans and dogs. Sodium proteinate and caseinate completely inhibited the flatus activity of whey solids or meal extractives. Commercial food-grade preparations of isolated soybean protein did not produce flatus.

In vivo and *in vitro* studies show that flatus is produced via activity of intestinal microflora following ingestion of flatus-causing foods. Isolated

cultures of the microflora of the colon of dogs are now being used in an assay for the flatus factor.

These results suggest that a useful solution to the flatus problem may soon be achieved; i.e., addition of sodium proteinate or caseinate to the food. Further work will be needed to confirm the present findings and to evaluate the practical value of this solution to the problem. Development of a rapid *in vitro* assay for flatus should greatly accelerate successful conclusion of this work.

2. Full-fat soybean flour. The Agency for International Development has authorized support of a project covering engineering research on production of full-fat soybean flour. This research continues and expands studies begun under the UNICEF Cooperative Program. Preliminary studies under this new project have been directed toward investigation of atmospheric steaming, water-immersion cooking and dry heating or roasting as possible simple methods for producing soy flour in countries having minimum facilities. The initial moisture content was shown to be a critical factor in achieving very rapid cooking with minimum protein denaturation. The pediatric evaluation of extruder-cooked full-fat soybean flour, conducted by UNICEF in Taiwan, is nearly complete. Results are very favorable and almost identical to those with cow's milk.

3. Studies on miso and shoyu. These studies are being conducted by several foreign institutions under PL 480 grants.

Results of large-scale miso fermentations at the Central Miso Institute, Tokyo, Japan, showed that the number of yeasts is much greater in fermentation of soybean grits than in fermentation of whole soybeans and that miso from grits scored higher in organoleptic tests than did miso made by the traditional method. At Bar-Ilan University, Ramat Gan, Israel, defatted soybean flakes were used successfully to produce a Japanese-type miso. Use of commercial enzymes enabled shortened fermentations. Rice koji (used as a "starter") could be replaced with koji made from corn and other cereals.

In the search for better strains of the organism *Saccharomyces rouxii* for use in making miso and shoyu (soy sauce), a large number of strains have been evaluated in terms of salt tolerance, flavor, alcohol formation and growth in a high nitrogen medium. Endeavors to find a key compound that could be used to characterize the total flavor in shoyu were unsuccessful. This research is being conducted by the Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan.

4. Quality of isolated protein for use in Israeli-type foods. In studies conducted under a PL 480 grant at the Israel Institute of Technology, Haifa, Israel, investigation of several processing variables resulted in improved yields, color, taste, nutritive value, and functional properties of isolated soybean protein. The pilot-plant data obtained are of

particular significance to soybean protein technology as a basis for improving and expanding the use of soybeans for food in developing countries.

5. Chinese cheese (sufu). Studies have now established that Actinomucor is the fungus used in the commercial production of sufu in Hong Kong and Taiwan. However, in preparation of sufu in the home a variety of species of Mucor are involved. Both Actinomucor and Mucor species were found to produce proteinase and alkaline phosphatase. In addition, certain isolates had active lipases. This research is being conducted under a PL 480 grant by the Institute of Chemistry, Academia Sinica, Taipei, Taiwan.

C. Feed Products

1. Effects of saponins on nutritional quality of soybean feeds and foods. In research under a PL 480 grant at Hebrew University, Rehovot, Israel, a new saponin has been isolated from soybeans and characterized. Its aglycone has been designated soysapogenol E. Soysapogenols A, B, C, and D were isolated some 15 years ago by Swiss workers. The new soysapogenol is a triterpene alcohol similar to soysapogenol B, differing only in that it has a hydroxyl group at C_{21}.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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PEANUTS PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of their high price the domestically produced peanuts are used primarily (currently about 63 percent of the crop) in foods such as peanut butter, confections, bakery goods, and roasted and salted nuts. A critical problem in the utilization of peanuts, which has recently been made more clearly evident, is the sporadic contamination of peanuts by toxin-producing strains of common molds. The possibility of toxins entering foods intended for human consumption, as well as feedstuffs, is of the utmost concern. Intensified research is therefore urgently needed on the isolation, identification, evaluation, control, and inactivation or removal of mold toxins such as aflatoxin which may develop in peanuts and processed peanut products. New type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets for peanuts; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts which have been cured slowly in the field. Information is needed as to the physical and chemical characteristics of those chemical constituents in peanuts which affect flavor, aroma, and other important properties of the processed products, as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut proteins and associated materials could similarly lead to the development of new concepts and new uses.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic chemists, biochemists, analytical chemists, a microbiologist, and chemical engineers engaged in both basic and applied studies on peanuts and peanut products to increase consumer acceptance and extend markets for peanuts.

Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. As a part of the Seed Protein Pioneering Research Laboratory's research on various seed proteins, fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins. In other in-house research, peanut constituents and their modification by processing that influence nutritive properties and consumer acceptance of processed peanut products are studied. Current phases of this research include investigations of the lipid or lipid-soluble constituents of peanuts and processed peanut products involved in the genesis of peanut flavor and aroma; and isolation, identification,

evaluation and control of fungi and toxic fungal metabolites which may develop in peanuts and its processed products. The Crops Research Division of ARS, the Consumer and Marketing Service, and several State Experiment Stations cooperate in the research by providing samples of peanuts of known variety and history. The Pharmacology Laboratory at the Western Regional Research Laboratory, Albany, California, and the Food and Drug Administration cooperate in certain biochemical aspects of the research.

Additional research on chemical composition and properties is being carried out under contract at Evans Research and Development Corporation, New York, N. Y., on the isolation, identification and characterization of flavor and aroma components of processed peanut products; at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of the relation of the carbohydrate, amino acid and protein components of the peanut to the formation of flavor and aroma during roasting; at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on a study of the limiting environmental conditions for the elaboration of mycotoxins in peanuts; and at the Agricultural Experiment Station, Texas A&M University, College Station, Texas, to develop information relating processing methods, preprocessing history, distribution of immature, mature and germinating peanuts, and external conditions such as mold incidence as they affect consumer-use properties of processed peanut products.

New and improved food products and processing technology are being developed in research conducted at New Orleans, Louisiana. One important line of research is concerned with the development of economically feasible methods for the inactivation or removal of aflatoxins from contaminated peanuts and peanut products to permit their utilization in foods (and feeds). Cooperation is maintained with the Crops Research Division, ARS, Market Quality Research Division, ARS, State Experiment Stations, the Pharmacology Laboratory of WU, the Food and Drug Administration, industry, and nutritionists in USDA, at universities and elsewhere, in connection with this research. Other research, supported by the Agency for International Development, involves a study of the preparation of peanut flours and their derived products for human consumption in developing countries. Cooperation is maintained with UNICEF for arranging nutritional evaluations of experimental products in developing countries, and with the Human Nutrition Research Division, ARS, for evaluating certain of the products. Other research is concerned with the development of low-fat peanuts having acceptable peanut flavor and texture characteristics. The possibility of removing aflatoxin, if present, by applying certain treatments during processing will also be determined in connection with this work. Informal cooperation is maintained with peanut suppliers and processors, and with nutritionists and home economists for evaluation of experimental products as required.

Additional research on new and improved food products and processing technology is being carried out under contract at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on the development of peanut products for use in preparation and fortification of processed and

convenience foods; and at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of sterilizing or inactivating treatments in conjunction with artificial drying and curing of peanuts to develop processing conditions needed for producing mycotoxin-free roasted peanut products of optimum quality.

The Federal in-house scientific research effort in this area totals 14.4 professional man-years. Of this number 7.6 is devoted to chemical composition and physical properties and 6.8 to new and improved food products and processing technology. Contract research involves an additional 5.8 man-years, 4.1 being on chemical composition and physical properties and 1.7 being on new and improved food products and processing technology.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations have a continuing program of research aimed at discovery of new uses for peanuts. In recent years a portion of this program has been directed to fundamental studies on the fermentation products produced by fungi growing on peanut substrates. During the past year, this work has been expanded to include determination of the sources and prevalence of fungi responsible for mycotoxin development in Southwest Spanish peanuts. The effect of field damage on subsequent infection by toxin elaborating fungi is being evaluated in relation to curing, handling, and marketing methods. Attention is also being given development of methods for preventing mycotoxin elaboration during post-harvest processing and marketing.

With the inception of mechanized harvesting and curing processes for peanuts some 15 years ago, the problem of "off-flavors" in raw and processed peanuts and peanut products has been of increasing concern to the industry. Several stations are investigating the source(s) and cause(s) of objectionable flavors in peanuts. For example, the type of off-flavor which arises when uncured peanuts are subjected to high drying temperatures is distinctive. Investigations have shown that levels of this off-flavor development in peanuts is a function of the curing temperature, time of exposure to heat, moisture content, and stage of maturity of the kernels. Some 21 volatile compounds have been isolated from this type of peanuts.

Other composition studies seek to determine the factors in peanuts which are responsible for the differences in susceptibility to various types of oxidative rancidity development. Work is also continuing on effects of production practices and storage conditions on the chemical, biochemical and physical changes which occur in peanuts and the relationship of these changes to odor, flavor and nutritive factors.

Studies on the flavor and aroma of peanuts involve consideration of the agronomic and biochemical factors responsible for the flavor of peanuts and peanut butter. Attempts to characterize the substances responsible for the aroma and flavor developed on roasting continue. Efforts to identify and quantitate the components of the aroma fraction have resulted in

identification, by gas chromatographic techniques, of some of the carbonyl compounds produced when precursor fractions are pyrolyzed.

Product development work is carried out in an effort to extend the use of peanut butter, salted peanuts and peanut oil by improvement of present products or through development of new products. Variables in processing conditions are studied to determine effects on product quality. As a part of a program for using peanut protein preparations in foods to improve their nutritive quality, peanut protein fractions are being used in food formulations. Attempts are also being made to develop new peanut items for the diet. In one approach, peanuts are dried at low temperatures and the oil removed to yield lower calorie items. Other flavors are then added to further vary the characteristics of the items. Use of peanut oil meal as a source of protein for swine and chicks is being evaluated. Growth rate, feed efficiency and various carcass quality characteristics are measured.

The station program on peanut utilization involves approximately 5.3 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. In pioneering research conducted in the Seed Protein Pioneering Research Laboratory, important advances have been achieved in determining the ultrastructure of quiescent seeds, in developing and improving methods of enzyme and protein research, and in studying protein synthesis in seeds.

A reliable and versatile methodology has been developed for the determination of the ultrastructure of quiescent seeds. With the development of the concept of aleurins (proteins contained within aleurone grains), interest has increased in determining the ultrastructure of the quiescent state of seeds and especially the conditions of the various organelles. Previous methodology had required that seeds be wetted for some period before being studied. This introduced the possibility of changes of the type which occur in the early stages of germination. It is now possible to study seeds extensively by permanganate fixation. These studies have shown the universality of aleurone grains; have shown how they develop in the premature seeds and verified the vacuolar origin of such grains; and have shown that many of the present pictures of protein bodies may be artifacts since they can all be produced in the cotton embryo by appropriate methods of fixation. In some instances lumps of electron-dense material are found in protein bodies; these are now being explained as caused by precipitation of the protein. It was shown that the mature aleurone grains contained the necessary material to dissolve their protein in a small quantity of water.

Electron micrographs of peanut cotyledon infected with Aspergillus flavus

show the micella of the organism. One of the interesting points is that the lipid particles (the spherosomes) are attacked first, leaving the aleurone grains intact in many instances.

In addition to staining with permanganate it has now become possible to stain with osmium, which reveals much more of the structure of the seeds. This has heretofore not been possible with oilseeds, but the methodology has finally been developed; the fine detail achieved by this method of staining can now be done in dry seeds as well as any other tissue.

Advances have been made in preparative electrophoresis on polyacrylamide gel to the point where the equipment is now operating routinely. Equipment for preparative electrophoresis was built, based on the experience gained with small column equipment. The new column will handle 20 to 30 milligrams of proteins at a time during a 16-hour period; it is fully automatic; maintains constant pH; maintains constant ion population in both electrode chambers; monitors and collects the effluent from the bottom of a 5 millimeter column. The same polyacrylamide gel column can be reused: columns have been used for as long as 400 hours of operating time. With such a column it has been possible to purify arachin, the major protein of the peanut cotyledon, into a fraction which migrates as a single specie on polyacrylamide gel. In so doing, a nucleic acid fraction was removed from the original preparation. It is now being used routinely to prepare adequate quantities of pure arachin for further physical-chemical and chemical studies.

The microcalorimeter designed and built at this laboratory was used to study the migration of glucose through a living membrane. With hemoglobin as a model, it has been possible to study the heat of protonation and in this way to determine the condition of the imidazole groups in the protein.

One of the problems in calorimetry is the length of time taken to equilibrate the reaction vessel. A new calorimeter was completed which uses the Peltier effect to cool the calorimeter so that one can compensate the heat produced in the actual reaction by a known amount of electrical current. This instrument has two advantages over previous ones: first, it allows one to determine more accurately the major portion of the heat; secondly, it allows for more rapid equilibration, which permits many more experiments with the same equipment and experiments with heat-labile materials.

A soluble derivative of edestin has been prepared. Edestin, the major globulin of hempseed and one of the oldest known and best studied of the seed proteins, is quite insoluble in buffers at low ionic strength and neutral pH: less than 1 milligram per milliliter is soluble under these conditions of room temperature. A method was devised to modify edestin by chemical reaction to increase its solubility. D, L-alanyl residues were polymerized onto the free amino groups of the protein. Although such a technique had worked well with other proteins, it did not work with edestin until the protein was first put into a solution of sodium dodecylsulphate (SDS), after which the polymerization reaction was conducted. Under such

conditions the solubility was increased to over 60 milligrams of protein per milliliter. There is an optimum concentration of SDS; at higher concentrations, the protein is not modified. It will now be possible to purify edestin by many of the techniques available to protein chemists and to study the properties of a homogeneous preparation of this modified protein.

A beginning has been made in studying some reactions of methionine in peptides. Methionine is more reactive than many had ordinarily considered and can be easily oxidized to the sulfoxide and sulfone. Investigations were conducted on the reaction of methionine in model systems, particularly the formation of sulfonium salts of alkyl halides.

In the course of these investigations another reaction was discovered. When the sulfonium salt is dried to remove excess solvent, there is a reaction which results in the destruction of the methionine moiety with the concomitant linkage of the substituents on the amino and carboxyl groups of methionine. One could imagine that if the same sort of rearrangement took place in the protein chain, one could remove methionine from a chain and shorten it by one amino acid, all in the same operation. Work is continuing to determine the generality of this reaction.

Seeds are an excellent model for the study of protein synthesis since many enzymes are synthesized de novo on germination. One such enzyme is lipase in oilseeds: it does not exist in seeds such as cottonseed or peanuts but is found after four to six days of germination. Even in the castor bean where there is considerable lipase activity in the resting seed, much more is developed on germination. Synthesis of this enzyme was studied in excised (distal halves) cottonseed tissue. It was found that there is a requirement for axial tissue for the synthesis to take place; the axial tissue can be replaced by gibberellic acid. Under conditions where gibberellic acid promotes the synthesis of lipase in distal halves of seeds, aflatoxin will inhibit this protein synthesis. Actinomycin D will also inhibit this protein synthesis.

There are differences among seeds. Some cottonseeds do not require gibberellic acid for the distal half to synthesize the enzyme; in these seeds, the synthesis is not inhibited by aflatoxin. Other samples of cottonseed do not undergo any synthesis in the absence of gibberellic acid; here the synthesis is inhibited by aflatoxin. A third sample was found to be intermediate between the two. It would seem that either conditions of maturation or storage cause these differences in the protein synthesis pattern.

Most of the activity of aflatoxin has been described heretofore in animal systems. The aforementioned research on protein synthesis has indicated a plant model for studying the effect of aflatoxin on protein synthesis. Moreover, this model seems to be excellent for studying the mechanism of action of gibberellic acid.

In the course of this investigation it was shown that regardless of whether

or not protein synthesis takes place, in all instances the free amino acid pool is the same. Further work showed that proteinases are present in the ungerminated cotton seed; the availability of amino acids is not a critical factor in determining the extent of protein synthesis. (SU P1).

2. Identification of Constituents and Factors Influencing Flavor, Aroma, Color, Structure, and Nutritive Value of Processed Products. In basic research, the nonglyceride lipid-soluble constituents of peanuts and their processed products are being investigated with the ultimate objective of expanding utilization. A method was sought for detecting fractions of peanut oil that may affect the development of aromas and flavors during roasting. Peanut-like aromas and flavors develop only when peanut dry matter is roasted in the presence of oil--any oil or oil-fraction tried, including USP heavy mineral oil--whereas oil-free peanut meal and flakes develop a scorched aroma when dry-roasted. Oil or oil-fractions heated alone, however, do not acquire a peanut-like aroma. Separation of the minor nonglyceridic components of peanut oil from the unhydrolyzed oil has been unexpectedly difficult. Separation of these components by methods used for extracts of animal organs has not been as effective as the literature would lead one to expect. Repeated batchwise partition between hexane and acetonitrile-methanol mixtures have been found to be more efficient for enrichment of nonglyceridic components of crude peanut oil than either batchwise adsorption and elution, batchwise partition between other solvent pairs, or continuous liquid-liquid partition. Column chromatography has been investigated further for separation of minor components of peanut oil. Silica gel columns developed with 1,2-dichloroethane containing increasing amounts of methanol have given the best separation, although most column fractions obtained to date are still mixtures. Gradient elution is less effective than stepwise elution. Milligram amounts of two microcrystalline materials have been obtained but have not been separated successfully from the accompanying oils. Crystallinity has been lost on subsequent manipulations before sufficient purification had been effected for characterization. Infrared curves of all fractions obtained in moderate purity have indicated either hydrocarbons or esters. Work on identification will be continued under a revised line project. (S4 1-109).

In contract research on the constituents responsible for flavor and aroma in roasted peanuts, conducted by Evans Research and Development Corporation, the extracts from a five-hundred pound batch of peanuts have been separated into acidic, phenolic, amine, and neutral fractions. An extraction sequence was devised whereby odoriferous acids and phenols were isolated from the methanol-soluble concentrate. The resulting acids were examined by gas chromatography, descending paper chromatography, and thin-layer chromatography of p-phenylphenocyl derivatives. Propionic, butyric, isobutyric, hexanoic, heptanoic, and lauric acids were identified, in addition to acetic and isovaleric acids, as previously reported. Other acids are evidently present; although one has been isolated as sharply melting crystals, it has not been identified. When the acidic fraction was further examined by column chromatography on silicic acid, an odoriferous material appeared as one elution peak from the columns, but paper chromatography indicated that it was a

mixture of several components.

By paper and thin-layer chromatography, at least six phenols have been shown to be present, though none have been identified. Further work with the phenolic fraction resulted in the separation of several components in small quantities. Infrared spectral data and other properties revealed that two of these appear to be aliphatic lactones rather than phenols, a development that would account for earlier failures to prepare phenolic derivatives from these fractions. An amine fraction consisting of 0.6 gm. of a brown oil has been isolated but has not yet been examined. From the neutral fraction, beta-sitosterol has been isolated and carbonyl derivatives--one of which might be a derivative of crotonaldehyde--have been separated and purified.

An attempt was made to isolate aroma precursors by a procedure involving solvent extraction, dialysis, and liquid-liquid extraction. Two fractions obtained gave aromas reminiscent of roasted peanuts when heated. One fraction, however, produced an aroma which more strongly resembled chocolate. The work on flavor and aroma components is now being extended to include the Southwestern Starr variety, a Spanish-type peanut, in addition to Southeastern peanuts. (S4 1-106(C)).

Research complementary to the preceding project is being conducted under a contract awarded to the Agricultural Experiment Station, Oklahoma State University of Agriculture and Applied Science: an investigation of the relation of the carbohydrate, amino acid, and protein components of peanuts to the formation of flavor and aroma during roasting. Peanuts of the Argentine variety, whose genetic background is known, were grown, harvested, and cured under four conditions (windrowed, and artificially at 90F, 105F, and 120F). These controlled conditions were not associated with significant differences in total oil and protein contents. However, analyses of "flavor precursor" fractions showed that higher curing temperatures greatly increased the loss of sugars, amino acids, and peptides. Representative samples were stored under three conditions (ambient, 36F, and 70F) in both the shelled and unshelled states. Data were recorded on irrigation; daily precipitation; temperatures during the growing period; and curing, comprising temperatures, relative humidities, and kernel moisture contents. Evaluation of methods for estimating maturity revealed that two proposed methods--screen size and pod characteristics--were unsatisfactory. Efforts will be made to correlate the organoleptic and chemical parameters with curing and storage conditions, data which are valuable in selecting the optimum environment during these important stages of processing. (S4 1-119(C)).

3. Investigation of Occurrence, Determination, and Properties of Fungi and Toxic Fungal Metabolites That May Develop in Peanuts and Their Processed Products. Several projects have been initiated to investigate different facets of the problems generated by contamination of peanuts by mycotoxins, a development of major importance to the peanut industry. A number of these facets were studied in the first project.

First a survey of the prevalence of aflatoxin in peanut stocks held by CCC was made on 112 samples from 16 warehouses in five states, representing three types and four grades. Aflatoxin was present in peanuts from all areas; although the aflatoxin content of peanuts from various geographical locations was not demonstrably different, there was a decided difference among grades. The amount of aflatoxin B_1 ranged from 3 to 2,250 parts per billion. Also assayed for aflatoxin were 21 samples of No. 2 peanuts, part of a 150-sample survey. In laboratory experiments, as much as 475,000 ppb of aflatoxin B_1 has been produced on shelled autoclaved peanuts as the substrate. The aqueous acetone procedure for determination of aflatoxins, originally developed for analysis of cottonseed products, has proved to be applicable to peanuts, and a micro procedure permits determination of aflatoxin in a sample as small as one milligram. Thus aflatoxin content of different parts of a highly contaminated peanut cotyledon ranged from 60,000 to 4,000,000 ppb. This finding of individual peanuts containing large amounts of aflatoxins distributed in different parts of the kernel emphasizes the difficulty of adequate sampling and indicates that simple washing to remove aflatoxin is not feasible. However, it also affords the promise of salvaging the major portion of contaminated lots if a simple method of removing individual contaminated kernels can be devised.

A working standard containing the four aflatoxins, suitable for reference in assaying for aflatoxin by thin-layer chromatography, was prepared and supplied to about 150 laboratories requesting such a standard.

An important part of this research concerns cooperative swine-feeding tests. For the first test, five batches of peanut meals of about 1000 pounds each containing graded levels of 10 to 1400 ppb of aflatoxin B_1, were prepared at SU; swine fed the meals at the University of California at Davis have now been slaughtered, and various histopathological tests are now underway at WU. For the second test, four batches of peanut meal (total weight 8,250 pounds) that contained graded levels of 36 to 5000 ppb of aflatoxin B_1 were prepared at SU. In this case, about 60% of the aflatoxin used was supplied by NU. After the swine-feeding tests are completed at Davis, WU will conduct the requisite biological tests.

In still another phase of the research, three pilot-plant extraction runs were made with peanuts to adapt acetone-hexane-water extraction for simultaneous removal of aflatoxin and oil from peanuts by prepress solvent extraction. Peanut meals containing between 2 and 30 ppb of aflatoxin and less than 1% oil were produced from peanuts containing about 300 ppb aflatoxin. Because of the importance of the aflatoxin problem, cooperation with industry and other government agencies is continuing on a number of projects of mutual interest. (S4-116).

The second related project, being conducted under contract to the Agricultural Experiment Station, Auburn University, concerns the limiting environmental conditions for the elaboration of mycotoxins in peanuts. Preliminary results indicate strain-temperature dependence in the production of

aflatoxin. When autoclaved shelled peanuts having 20% moisture were inoculated into aflatoxin-elaborating strains of Aspergillus flavus, incubation at 25° C. for 7-9 days produced the highest levels of aflatoxin. Production of aflatoxin decreased drastically at 20° C. and at 35-40° C. Aflatoxins were detected in the peanuts after 3 days' incubation and for the 21-day duration of the experiment. In liquid media, one strain of A. flavus produced most aflatoxins at 25° C., whereas another was most active at 30° C. Trace minerals and nitrogen also appeared to be critical. Magnesium and zinc were determined to be essential to aflatoxin synthesis in liquid cultures. Both organic and inorganic nitrogen sources were required for maximum aflatoxin yields. Potassium and ammonium nitrate were found to be the best inorganic sources of nitrogen, while glycine, glutamic and aspartic acids, phenylalanine, tyrosine, and tryptophan were good sources of organic nitrogen in the order named. This finding, with the indication of strain-temperature dependence, suggests that minor differences in the substrate (peanuts) may have profound effects on the elaboration of aflatoxin. Experiments on the influence of a number of variables will make use of the controlled humidity cabinets that were recently installed. (S4 1-121(C)).

The third line of related work is also being conducted under contract, this one to the Agricultural Experiment Station, Texas A&M University. Processing methods used for peanuts of known history will be investigated with respect to different growing and curing conditions to achieve high quality peanut products that are free of mycotoxins. The Starr variety of Spanish-type peanuts were grown with and without irrigation and pre-emergence treatment of the soil with fungicide. Records of rainfall and temperature were kept. Of the threshed portion of the crop, half was artificially dried at 120° F., and the other half, intended for drying at ambient temperatures, had to be partially dried by artificial means because of high humidity. The balance of the crop was field-dried in windrows. Preliminary analyses indicate that irrigation and fumigation improve the quality of raw peanuts, as measured by maturity, density, and crude oil content; in comparison with artificially dried peanuts, field dried lots had a higher percentage of mature kernels, but there was little difference in the crude oil content of these mature kernels. Analyses of raw peanuts will be continued, but the major effort will be on the evaluation of processed products by organoleptic and chemical techniques. (S4 1-120(C)).

B. New and Improved Food Products and Processing Technology

1. Peanut Flours and Derived Products for Human Consumption in Developing Countries. A study of the preparation of peanut flours and their derived products for human consumption in developing countries has been initiated with the support of the Agency for International Development (AID). Investigation of processing in the pilot plant indicated the feasibility of adapting the conventional prepress solvent extraction process to use of a mixed solvent (acetone-hexane-water). This promising method simultaneously extracts the oil, removes about 90-95% of the aflatoxin present, and produces a highly nutritious meal or flour product. Samples of these flours are being

prepared to be evaluated as foods; improvement of quality will permit higher percentages to be incorporated into bakery products and other formulations. Effort will be concentrated on the development of the simplest and most practical processes for small and medium sized plants to produce peanut flours of highest quality. (SU-0-0-3(AID)).

2. New Processed Products, Including Low-Calorie Peanuts and Peanut Flours, Meals, and Grits. A method has been developed for the preparation of low-fat, high-protein peanut products without the use of solvents. The peanuts are mechanically pressed to remove as much as 85% of the oil, expanded to their original size in an aqueous medium, dried, roasted, and salted. Conditions for these steps are being investigated. Two methods of drying and roasting that appear promising are the application of infrared heat to peanuts in a perforated rotating cylinder and immersion in hot oil. The information obtained to date should prove helpful in developing a commercial process. Objectives include improving the texture, appearance, and method of salting, and adapting the process for pilot plant and then commercial production of these attractive, low-calorie peanuts. (S4 1-126).

A contract recently awarded to the Agricultural Experiment Station, Auburn University, concerns the development of peanut products for use in processed and convenience foods. Peanut flours, meals, and grits, some having reduced oil content, will be prepared and from them a variety of foods--such as chips or flakes, milk or malted milk-type drinks, baking flour, ice cream, and other confectionery goods--will be developed and evaluated. Although work is not yet underway, steps have been taken to procure the peanuts and the equipment necessary for this research. (S4 1-118(C)).

3. Methods Developed for Inactivating or Removing Aflatoxin from Contaminated Peanut Kernels. Procedures are being developed to inactivate or remove aflatoxins from contaminated peanut kernels. Treatment with chemicals, especially those based on ammonia, appear to be effective in reducing the aflatoxin content of peanut meals without significantly altering their nutritive value. Anhydrous ammoniation produced good results: peanut meal containing 700 ppb B_1 assayed 17-25 ppb B_1 after being processed at 40 psig pressure at 160-170° F. for one hour. Ammoniation of peanut meats followed by hexane extraction was not as effective. Peanut meal treated with gaseous and aqueous ClO_2 by a cooperating chemical company showed no reduction in aflatoxin, whereas after meal was treated with acid-activated NaOCl (Textone), no aflatoxin B_1 was detectable. Although heat treatments also reduced the aflatoxin content, they may impair the nutritive value. The utility of various treatments will be investigated to develop practical methods of inactivating aflatoxin. Feeding studies will be conducted in cooperation with WU and other groups to better define conditions whereby aflatoxin is destroyed but the nutritive value is not impaired. (S4 1-133, Pending).

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TUNG PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

Problem. Tung oil has lost much of its traditional market in protective coatings to synthetic raw materials. New and improved industrial products from tung oil must be developed to recapture lost markets, maintain present markets, and provide new outlets for surplus tung oil. Basic information is needed on the chemical composition and properties of tung oil and its fatty acids, and on the chemical modification of these materials to permit more effective exploitation of their unique characteristics in protective coatings, agricultural and industrial chemicals, surfactants, and plasticizers.

USDA AND COOPERATIVE PROGRAM

Research in the area of chemical composition and physical properties is in progress under a grant of P.L. 480 funds to the National Chemical Laboratory, Poona, India, for investigations of the effect of heat on tung oil and its derivatives, and characterization and identification of compounds resulting from heat treatments, to extend the utilization of tung oil (project duration - 5 yrs.).

The Federal in-house scientific research effort in this area has been terminated. P.L. 480 research involves 1 grant for research on chemical composition and physical properties.

The following line of work was terminated during the year: The development of exterior and interior intumescing, fire-retardant coatings based on tung oil and tung oil derivatives.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations reported no research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Structural Factors, Properties, and Reactions of the Proteins. The composition, structural factors, properties, and reactions of oilseed proteins and associated materials are being investigated in research conducted by the Seed Protein Pioneering Research Laboratory. The basic information developed should lead to new concepts and possibly new applications for oilseed proteins, including tung protein. Since peanuts were found to be a particularly suitable experimental material and were employed for much of the early pioneering research on seed proteins, the report of progress in this research is given in Area No. 7, "Peanuts Processing and Products," as in the previous report.

2. Basic Investigations of the Effect of Heat on Tung Oil and Its Derivatives. At the National Chemical Laboratory in Poona, India, research to investigate the effect of heat on tung oil and on its derivatives is being conducted under a P. L. 480 grant. Drastic heat treatment of methyl eleostearate afforded low yields of a complex mixture of monomeric materials, shown to contain at least five different monomers. Heating methyl esters of α- and β - eleostearic acids at lower temperatures for longer periods of time gave unexpectedly higher yields of cyclic monomers from the β ester but not from the α ester. Separation yielded two principal monomer fractions to which two alternative structures have been tentatively assigned. Attention is being directed to a study of catalysts and reaction conditions to try to get reproducible yields. The fundamental information generated by this research is expected to aid in the development of new industrial uses for tung oil outside the protective coatings field. (UR-A7-(40)-12).

B. New and Improved Industrial Products

1. Intumescing Fire-Retardant Surface Coatings from Tung Oil Alkyds. Considerable progress has been made in the development of water-resistant, intumescing, fire-retardant coatings based on tung oil and its derivatives, research conducted with the cooperation and support of the U. S. Army Engineer Research and Development Laboratories and the Pan American Tung Research and Development League. Recent experiments have illustrated the importance of a suitable vehicle and of the spumific and carbonific materials. For example, the vehicle synthesized with 33% tung oil appears to be the best type of vehicle for formulating highly water-resistant fire-retardant coatings with pentaerythritol polyurethanes, but the vehicle containing 17% tung oil appears best for formulating fire-retardant coatings with carbonific pentaerythritols. In addition to imparting much more water-resistance, some of these polyurethanes produce coatings having superior color and color retention, good drying and bonding characteristics, and other excellent conventional properties. The development of commercially successful oil-based fire-retardant coatings should not only significantly increase the consumption of tung oil but also greatly reduce losses of life and property.

This progress has been facilitated by modification of the SU 8-foot tunnel furnace to an elementary 16-foot tunnel furnace in which flame-spread can be measured. Since the results correlate well with results from the Underwriters' Laboratories' 25-foot tunnel furnace, only a limited number of coatings have had to be evaluated by costly and time-consuming trials in the longer furnace. A chemical company has duplicated the SU 16-foot furnace for its own use, and a major paint company has requested specifications for construction. (S4 1-113).

New and Improved Industrial Products

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CASTOR, SAFFLOWER, AND OTHER WESTERN OILSEEDS - PROCESSING AND PRODUCTS

Western Utilization Research and Development Division, ARS

Problem. To provide valuable diversification crops for the acreage withdrawn from the production of cotton, wheat, feed grains, and other surplus crops, we must expand the markets for crops such as castor and safflower. Large amounts of safflower are exported and research is needed to insure the continuance and expansion of this promising market. Also, these crops are so new to our agricultural economy that their market potential has not been adequately developed. Castor and safflower have good potential because of the unusual properties of their oils. The possibility of large-scale increases in the production of these oilseeds would be strengthened if high-quality feed products could be developed from the oilseed meals. Basic information is needed on the composition of the oils and of the meals left after extraction of the oil, and this, in turn, requires the development of adequate analytical methodology. Rapid and accurate analytical methods are needed to control and improve the processing of the oils and meals for food, feed and industrial applications. Research on chemical conversion of the oils and evaluation of the modified products is needed to find new or improved large-volume uses. The high percentage of linoleic acid (essential fatty acid) in safflower oil points to a rapidly expanding use as a food oil. But this same fatty acid imparts a high susceptibility to autoxidation. Research is needed to stabilize safflower oil in various food products. Improved procedures for decorticating and processing castor and safflower seeds are needed. There is a particularly critical need to remove or destroy the allergenic and toxic components of castor meal which presently limit its use to fertilizer. Research to isolate and characterize the constituents in castor and safflower meals is needed to develop non-toxic, non-allergenic feed and food products of high value. Particular emphasis should be placed on developing safflower meal suitable for human consumption, opening an entry into the increasing edible protein export market. Basic and applied research is needed to prepare chemically modified products from the meals for industrial applications, to develop economical procedures for carrying out the modifications, and to evaluate the modified products.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor and safflower seed at the Division headquarters at Albany, California, under contract in Arizona, and by P.L. 480 grant funds in India. Basic, compositional studies on castor seed meal are concerned with the resolution of its water-soluble proteins and determination of the nutrient properties for animal feed. Studies are conducted on the composition of castor and safflower oils and meals, and new analytical techniques are developed.

Applied research on castor meal has as its objective the development of economical methods for deallergenizing the meal without impairing its nutritive quality, to increase its value as an animal feed ingredient. Castor oil and its major constituent, ricinoleic acid, are being studied to provide for them new and improved industrial applications. Thus, methods are being developed for the preparation of various types of polyurethane foams incorporating castor oil or its derivatives. Procedures are also being devised for the preparation of chemical derivatives from ricinoleic acid, including ketones, acrylate esters, ω-hydroxy acids, and halogen- and phosphorus-containing glycerides. Several of the latter compounds may be useful for improving the flame-resistance of castor-based polyurethane foams of the type which may be used for building insulation. The utility of various polymerizable monomers, e.g., acrylate esters from castor oil for the production of synthetic polymers for use in rubbers, plastics, etc., is being investigated under contract. Research has been initiated on the composition of new and commercially promising safflower varieties. Detailed studies are underway to evaluate variation of fatty acid, amino acid, protein, fiber, etc. with the types of seed. Oils from new and established varieties are being studied for oxidative stability which is needed for large-scale food uses. The meals are being evaluated as protein sources in animal rations. Research under contract is underway on the types and amounts of natural antioxidants in the various safflower seed oils.

The Federal program of research in this area totals 9.6 professional man-years, including contract research equivalent to approximately 1.8 professional man-years per year. Of this total 5.6 are assigned to chemical composition and physical properties; and 4.0 to new and improved products and processing technology. In addition, two grants on applications of research are sponsored under P.L. 480.

PROGRAM OF STATE EXPERIMENT STATIONS

Castor and safflower are of interest due to the unusual properties of their oils and as possible replacement crops. State stations are investigating agronomic and harvesting problems. Utilization research is limited to nutritional and chemical evaluations of the castor plant being done in cooperation with USDA. Objectives include study of: the toxic and hemagglutinating protein, ricin; use of castor meal as a supplemental feed for large animals; the role of ricinine in metabolism and physiology of the plant; and isolation and identification of the compound(s) responsible for the foaming of aqueous extracts of castor beans.

There are approximately 0.1 professional man years devoted to this study.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Detection of Allergens. Research to develop methods for the qualitative and quantitative analysis of allergens from castor seeds was completed, and

attention directed toward adapting such methods to other problems, including detection and control of toxic metabolites of mold contaminants. In the course of the research, human allergies were successfully detected by application of patient serum to monkeys and other primates. The results correlate with clinical skin tests of the serum donors. The animal test method was also used to determine degree of deallergenation of castor bean pomace by novel processes. Applicability to other agricultural problems was demonstrated in the evaluation of 57 species of Euphorbiaceae being considered as potential replacement crops. These plants were examined for cross-reaction antigens to evaluate the risks of dust allergies similar to or cross-reacting with castor pomace allergy, risks that may be encountered if such plants are introduced for wide-scale agricultural development. Cross-reactions were observed. In addition, unequivocal tests confirmed earlier findings that chlorogenic acids from coffee or other sources are not allergenic and have no cross-reactions with castor allergy, as has been published elsewhere. Because chlorogenic acid occurs so widely in plants, the implications of its reported allergenicity could have had serious repercussions on market developments, particularly for fruits and vegetables.

2. Oilseed Components. Further compositional studies were conducted with 24 varieties of thin- and thick-hulled safflower seeds. Hull and fatty acid content were the main factors in seed variability. Hull content ranged from 50% to 18%, and oil content from 30% to 45%. Gas liquid chromatographic analyses indicated large differences in fatty acid content between varieties. Thin-hulled varieties contained about 80% linoleic acid and 12% oleic acid, whereas some thick-hulled varieties had as much as 83% oleic acid and only 10% linoleic acid. The difference in fatty acid content of oils attainable by varietal selection and development of safflower offers a great potential in developing specific oils for specific uses. Safflower oil for food use must be stabilized against undesirable polymerization at high temperature. Combinations of hydrogenation and antioxidant addition provided some protection, but basic investigations must continue.

Synthesis of acrylate esters of hydroxy acid derivatives resulted from various approaches utilizing acid- and base-catalyzed alcoholysis of acid chlorides and anhydrides, solvolysis of various alcohol derivatives, and direct esterification. A simple two-step process leading to good yields and high purity of methyl 12-acryloxystearate was developed and scaled up. The application of new methods for acrylate ester synthesis in high yields and purity will provide monomers for preparation of plastic coatings, lubricants, and other industrial products of high value. Several commercial dehydrogenation catalysts were evaluated for ketostearate preparation. The low cost of highly efficient dehydrogenation catalysts should make ketostearate an attractive industrial product.

Thin-hulled safflower varieties offer higher oil yields than thick-hulled seeds do, and the seed meal has higher feed value because of its smaller amount of indigestible hull. However, a very promising brownstripe, thin-hulled variety produces oil that has an off-odor and a brownish color from

hull pigment. Research is being conducted to eliminate the unpleasant odor and reduce the transfer of color to the oil. Large-scale decortication of safflower varieties produced kernel-free hull from which volatiles will be collected, concentrated, and analyzed by gas-liquid chromatography to provide leads for the study of off-color development in safflower oil. Good yields of high-protein, low-fiber flour were obtained from the thin-hulled safflower seeds. Contract research at the University of Arizona in Tucson was initiated to separate, purify, and characterize naturally occurring antioxidants in safflower oil. Plant breeders of the Arizona Agricultural Experiment Station are supplying new promising safflower varieties for evaluation. Information on oxidative stability of safflower oil from commercial and new varieties will be obtained.

B. New and Improved Products and Processing Technology

1. Product Developments. Rigid foams with good strength and insulating properties were prepared by a one-shot procedure using castor-based polyols directly with polymethylene polyphenylisocyanate. The procedure avoids preliminary time-consuming preparation of isocyanate-containing prepolymer, and it is less costly. With this procedure, castor-based polyurethanes reach a favorable competitive position relative to synthesized polyols from petroleum. We demonstrated that these foams can be made flame-resistant and non-burning by using brominated castor oil, and they are self-extinguishing when chlorinated castor oil is used. Preliminary work on phosphorus derivatives of castor oil has not yet yielded good non-burning foams.

At the University of Arizona, Tucson, contract research supported jointly by the Southern and Western Utilization Research Divisions is underway on polymerization and co-polymerization of selected monomers derived from oilseeds, preparation and characterization of new monomers, and preliminary evaluations of the polymers as industrial products. A large quantity of polyvinyl 12-hydroxystearate was prepared for use in polyurethane studies. The present contract is a continuation of joint support for the research at Tucson and will continue for five more years.

2. Animal Feeds. Primary consideration has been given to deallergenization of castor pomace to make castor a more valuable crop. Interrelationships of time, temperature, and lime concentration were determined in pilot studies. The higher the process temperature, the lower could be the process time and lime concentration necessary to effect acceptable deallergenization. Lime concentration of 8% with a one-hour process time at 120° C. was sufficient to obtain a satisfactory product. Lime treatment caused degradation and change in amino acid composition of castor meal. Lysine, arginine, threonine and serine were reduced, while glycine and alanine increased to a degree depending upon the severity of treatment. Arginine was partially converted to ornithine, and this conversion may afford a useful index of degree of deallergenization. If the index proves to be reliable in rigorous testing, it could substantially reduce the cost of analysis for production control in commercial deallergenization processes. A plant-scale trial of

lime-treating of castor meal was completed at the Baker Castor Oil Company's Los Angeles plant. Further testing on the plant-scale level must be done to complete the development of this process. Material has been prepared for feed evaluation. Additional pilot plant studies are in progress on ammonia and other basic treatments that show special promise.

Partially decorticated thin-hulled safflower seed produced good yields of high-protein (60%), low-fiber (3%) flour. When lysine and methionine were added to this meal, growth response was better in chicks than with any other protein source tested. When the protein level of the safflower-containing ration was reduced from 22% to 20% or 18% protein, growth rates decreased slightly, but results were still as good as those obtained with the higher protein positive control diets. Amino acid analyses on 25 different types of safflower seeds showed that lysine varied only about 10%. With the rapid increase in safflower production in the western United States, knowledge of food and feed values of the meal is essential if maximum value is to be obtained from this relatively new domestic crop.

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New and Improved Products and Processing Technology

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NEW CROPS - UTILIZATION POTENTIAL
Northern, Southern, Western, and Eastern
Research and Development Divisions, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potentials. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on byproducts from processing, such as oilseed meals.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a long-range continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful components and in detailed characterization and evaluation studies of selected components that have the greatest industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of

collecting trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical screening program to identify sources of unusual and potentially useful components such as oils, fibers, gums, amino acids and proteins. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research. This utilization research is divided among the four Utilization Research and Development Divisions.

The Federal scientific effort devoted to research on replacement crops at Peoria, Illinois, totals 27.1 professional man-years. Of this number 16.0 are concerned with chemical composition and physical properties; 8.7 with industrial utilization of new oilseeds; and 2.4 with industrial utilization of new gum and fiber plants.

Research at Peoria, Illinois, on chemical composition and physical properties (16.0 professional man-years) involves conduct of the program on screening uncultivated plants for unusual and potentially useful oils, fibers, gums, amino acids and other components; organic chemical characterization of selected fractions and components, especially new oils and fatty acids; and studies on properties of new plant fibers.

Research at Peoria, Illinois, on industrial utilization of new oilseeds (7.1 professional man-years) involves studies on processing of erucic acid oilseeds to obtain oil and meal and investigations on utilization of erucic acid and its derivatives. A research contract (1.6 professional man-years) is in effect with Southern Research Institute, Birmingham, Alabama, for studies on preparation and evaluation of polyamide resins derived from crambe oil.

Research at Peoria, Illinois, on industrial utilization of new gum and fiber plants (2.4 professional man-years) is concerned with development of methods for recovery of gums from plants; with evaluation of plant gums in industrial applications; and with studies on pulping new fiber plants and evaluation of the pulp in paper, structural boards and related products.

The Department also sponsors research in this area conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the Institute of General Chemistry, Warsaw, Poland, for determination of glyceride structure of erucic acid oils (5 years, 1962-1967); and to the Swedish Seed Association, Svalof, Sweden, to find new erucic acid oilseeds (5 years, 1963-1968).

The Federal scientific effort at the Southern Division devoted to research in this area totals 1.3 professional man-years. All of this effort is on chemical composition and physical properties.

The following line of work was terminated during the year: Preparation of chemically modified fatty acids or oils, from the potential new oilseed crops Cuphea, Limnanthes, and members of the Umbelliferae, suitable for evaluation as corrosion inhibitors, biologically active compounds, in plastics, or other industrial products.

At the Western Utilization Research and Development Division utilization research in this area has been discontinued at Albany, California. Contract research at Fargo, North Dakota, equivalent to about 0.4 professional man-years per year will be continued.

At the Eastern Utilization Research and Development Division, work on new crops was terminated June 30, 1965. In F.Y. 1965 this work totaled 4.3 professional man-years, and was concerned with a study of the oil obtained from the seed of an ironweed (Vernonia anthelmintica) of Indian and Pakastani origin and also recently (beginning in December 1964) with the seed oil from Euphorbia lagascae, an introduction from Spain. These studies have been in cooperation with the Northern Utilization Research and Development Division, the Crops Research Division, and the Western Utilization Research and Development Division. These oils contain epoxy fatty acids, potentially useful industrial chemicals.

PROGRAM OF STATE EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, pigments, drugs, tannins, essential oils, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention. New varieties of fruits, vegetables, and grasses better resistant to disease and drought are continually sought.

Basic aspects of this program involve study of the biochemical and physiological basis for differences in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbo-

hydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms. Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 8.4 professional man-years.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

Northern Division

1. Screening for new industrial oils. Since the last report, screening analyses were performed on 822 seed samples and 258 samples of oil were analyzed. Oils from four new species found to contain 12,13-epoxy-cis-9-octadecenoic (vernolic acid) were: Crepis vesicaria and C. kitaibelii (family Compositae); Cephalaria joppica (Dipscacaceae); and Valerianella radiata (Valerianaceae). The seed oils from these species contained 50, 53, 33, and 31 percent of vernolic acid, respectively. An additional Crepis (C. thomsonii) with high content (60 percent) of crepenynic acid was found. Impatiens edgeworthii contained 61 percent of the conjugated tetraenoic acid, parinaric acid. The highest concentration reported previously was 56 percent. Crambe seed selections from Texas AES showed oil content of 39.5-47.0 percent and erucic acid content of 55.4-58.7 percent. Seed oil of Acanthosyris spinescens contained 34 percent of normal C_{17} acids. These studies provide essential guidance to agronomists in selection of species for experimental planting and to utilization research scientists in selection of the most promising oils for further study and evaluation.

Under a PL 480 grant to the Swedish Seed Association, Svalof, Sweden, scientists have measured erucic acid content of a large number of samples of seed oils and have determined amounts and types of thioglucosides in the seeds. Genetic variability in erucic acid content of crambe oil was found to be much less than that of Brassica plant seeds but still sufficient to offer encouragement that higher erucic strains of crambe can be developed. High erucic lines of white mustard and of rapeseed have been selected that contain just over 60 percent erucic acid. These will be used in attempts to achieve still further increases in erucic acid content.

2. Characterization of new seed oils and components. Laballenic acid, which comprises 16 percent of the fatty acids of Leonotis nepaetifolia seed oil has been fully characterized as 5,6-octadecadienoic acid. Preliminary characterization of the conjugated tetraenoic acid from the seed oil of Impatiens edgeworthii indicates that it is cis-9,trans-11,trans-13,cis-15-

octadecatetraenoic acid. Nine acetylenic fatty acids were found in the seed oil of Acanthosyris spinescens. Seven of the nine are new. One component acid of the seed oil of Acanthosyris spinescens has been characterized as the previously unknown 7-hydroxy-trans-10,16-heptadecadien-8-ynoic acid.

At the Institute of General Chemistry, Warsaw, Poland, under a PL 480 grant, hydrolysis with pancreatic lipase was applied to crambe oil and to fractions separated from it by column chromatography on alumina. Results confirmed earlier work in demonstrating that erucic acid is nearly all esterified to the primary alcohol groups of glycerol (α-position). However, one crambe oil fraction, representing about 12 mole percent of the oil, had almost 25 percent of the erucic acid in the β-position.

3. Characterization of the components of crambe. Either (R)-goitrin or nitrile (1-cyano-2-hydroxy-3-butene) and related products, or both, could be produced in enzymatic hydrolysis of thioglucosides in crambe meal, depending upon pH, temperature, amount of water and previous treatments of the meal. Increased formation of (R)-goitrin and decreased formation of nitrile and related products were observed during endogenous enzyme hydrolysis of crambe meal that was obtained from aged seed, subjected to high storage temperatures, or subjected to a dry heat treatment. The crystalline polypeptide crambin is, like crambe myrosinase, insoluble in water, but it is not the enzyme per se. In enzymatic hydrolysis the presence of 2-mercaptoethanol favored nitrile formation. Analysis of 16 new accessions of crambe for total thioglucosides showed no significant variation. Sinapine was identified as the major cationic fluorescent substance in crambe meal extracts. Enzymatic hydrolysis of thioglucosides in the meal did not change the sinapine content. Sinapine from crambe was identical to that from rape and could be completely removed by extraction of crambe meal with hot methanol. Information is being steadily accumulated on which an effective process for producing palatable nutritious crambe meal can be based. The present results extend our knowledge of the complex chemistry of crambe enzymes and of thioglucoside conversion and provide more of the detailed background needed for controlling processing and product quality. The possible relationship of sinapine, a bitter-tasting substance, to palatability of crambe meal is an interesting lead that may prove highly significant.

Western Division

Dimorphotheca and Lesquerella Seed Oils. Seed oils of Dimorphotheca and Lesquerella species and their derivatives are under continuing analytical investigation. Correlation data between far ultraviolet absorption and structure of fatty acid esters were obtained for 32 compounds to provide useful information about fatty acid derivatives. Substantial quantities of seed oils of Lesquerella fendleri and L. gordonii were hydrolyzed and analyzed for hydroxy acid contents. Methyl ethers of hydroxy acid derivatives were prepared and evaluated by optical rotatory dispersion. Optical

rotatory dispersion studies provide a rapid method for assigning absolute configurations to hydroxy acids. To date 14 derivatives have been studied which support earlier conclusions concerning the absolute configuration of 9-hydroxystearate. Absolute configurations of 14-hydroxyeicosanoate from lesquerolic acid and 12-hydroxystearate from densipolic acid were also determined. Low temperature alkaline cleavage techniques were developed to obtain improved yields of short-chain hydroxy acids to use as starting materials for film and fiber polymers. Keto esters were prepared from dimorphecolic and lesquerolic acids at low catalyst concentrations. The effect of hydroxyl group position on reactivity was noted.

B. Industrial Utilization of New Oilseeds

Northern Division

1. Studies on utilization of crambe meal. A 196-day beef cattle-feeding trial of crambe meal from the commercial-scale run reported last year was conducted at the University of Nebraska. Initially, poor palatability resulted in poor consumption. With the aid of molasses and pelleting, good feed intake and efficiency were obtained with 33 percent crambe meal in the protein supplement. At levels of 66 percent or 100 percent, poorer palatability and smaller gains were noted. However, at all levels feed efficiencies and carcass grades were comparable to those obtained with soybean meal. No thyrotoxicity or other abnormalities of organs were found in crambe-fed animals.

Ammonia treatment of crambe meal appeared to eliminate toxicity when fed to chicks in a 4-week test at the 20-percent level. University of Nebraska reported improved acceptability of the ammonia-treated meal to cattle. Analytical tests showed absence of thiooxazolidone and sinapine.

In feeding studies with rats, full-fat crambe meal enzymatically converted at low moisture levels and extracted with aqueous acetone supported growth at 90 percent of the growth rate of control animals. When fed at 28 percent of the diet, no palatability problem was evident. Similar treatment of defatted meal gave a product that supported rat growth at 88 percent of that of the controls over a 90-day period. Autopsies revealed no abnormalities of organs.

2. Studies on utilization of erucic acid. Adducts of brassylic acid with from 1 to 100 moles of ethylene oxide have now been synthesized. The products cover the whole range of oil/water and water/oil surfactants and are comparable in surface activity to analogous commercial products. Oxidative ozonization of a water emulsion of erucic acid dissolved in propionic acid was successfully effected by continuous processing in the pilot plant of an industrial concern. The product (185 pounds) was high purity (>95 percent) brassylic acid. Brassylate esters of mixed alcohols were superior

to the dicyclohexyl ester as low-temperature plasticizers for polyvinyl chloride (PVC) in tests conducted at the Eastern Division. Vinyl 2-methylpentyl brassylate was prepared for tests as an internal plasticizer for PVC.

At Southern Research Institute, 13-aminotridecanoic acid was prepared and converted in small-scale trials to nylon-13. 1,13-Dicyanoundecane has also been successfully prepared, but reduction to diamine revealed difficulties requiring further study. In a comparison of nitric acid oxidation and ozonization for cleavage of erucic to brassylic acid, nitric acid oxidation gave a higher yield but was difficult to control. Also, special treatments were necessary to remove nitrogenous impurities from the product.

A memorandum of understanding was negotiated with McClouth Steel Company for tests of crambe oil as a lubricant in continuous casting of steel, a potential market of 6 to 8 million pounds per year. This study, which consumed oil at the rate of 2,500 pounds per month, showed that crambe oil performed exceptionally well in this application. In fact, if an adequate supply of oil were available, large amounts could readily be marketed for this purpose. Interest in acquiring quantities of crambe oil for still other industrial end uses has been expressed by several companies. It is evident, therefore, that prospects for industrial utilization of crambe oil are excellent, and that interest continues to grow. It is noteworthy that the supply of oil is proving to be the limiting factor.

Western Division

Industrial Products from Hydroxy-unsaturated Oils. Contract research at North Dakota State University is concerned with fundamental information on drying properties of dehydrated hydroxy-unsaturated oils and their relationship to quality in specialty coatings. Seven Dimorphotheca and one safflower isocyanate films were tested for drying properties, hardness, adhesion, and scratch resistance. Long-term weathering and fire cabinet tests show that Dimorphotheca oil in suitable combination with isocyanates and polyols, yield coatings with excellent to superior properties. The good properties of some of these new experimental products and the added fundamental information from the tests should help stimulate industrial interest in Dimorphotheca oil if varieties can be selected and cultural and harvest practices advanced to bring about a reliable commercial supply. Castor oil dehydrated with sulfuric acid catalyst was utilized as a model for evaluation of changes occurring during the drying of dehydrated Lesquerella oil films. Fundamental information on drying properties of dehydrated hydroxy-unsaturated oils has been obtained, including attenuated total reflectance and direct transmittance infrared spectrophotometric values and peroxide values by which chemical changes associated with after-tack of dehydrated oil films can be elucidated.

Southern Division

Industrial Products from Oilseeds Containing Capric Acid or Unusual Long-Chain Unsaturated Acids. In the research on new oilseed crops, work was completed on the preparation of chemically modified fatty acids or oils to be evaluated for use as industrial materials.

Uses for Cuphea llavea oil, whose major constituent is capric acid, were sought. The oil was extracted from seed for evaluation in the preparation of alkyd resins and as a plasticizer for polyvinyl chloride. Though unsuitable as a primary plasticizer, Cuphea oil improved the low temperature properties of polyvinyl chloride when used as a secondary plasticizer in conjunction with dioctyl phthalate (DOP). Derivatives of capric acid were also submitted for testing as antimicrobial agents and as growth regulators to retard the flowering of tung trees.

Essentially pure methyl 5-eicosenoate and pure methyl 5,13-docosadienoate and their acids were prepared from Limnanthes mixed methyl esters. The former acid was used in the preparation of derivatives for evaluation. One-hundred-gram quantities of the vinyl esters of chlorinated 5-eicosenoic acid and chlorinated Limnanthes mixed fatty acids were prepared for evaluation as copolymers for vinyl chloride. A hydroxy delta-lactone prepared from 5-eicosenoic acid may be a versatile intermediate in the preparation of other materials. A sample of Limnanthes douglasii seed grown in Alaska and analyzed for oil, moisture, nitrogen, and fatty acid composition of the oil was similar to seed grown elsewhere. The predominant acid present in the oil was 5-eicosenoic.

The vinyl ester of the adduct of petroselinic acid (a major acid of Umbelliferae seed oil) and hexachlorocyclopentadiene, prepared under this project, was shown under contract research at the University of Arizona to have utility as a copolymer for vinyl chloride. Four substituted amidostearic acids were prepared from petroselinic acid and submitted for screening as antimicrobial agents. Other nitrogen-containing derivatives of petroselinic acid were sent to a major company for evaluation as corrosion inhibitors. A sample of fennel seed, grown in Texas, was analyzed for moisture, oil, total nitrogen, and fatty acid composition, and found to be similar to samples of fennel seed from other areas. (S5 5-52).

Eastern Division

Industrial Use of Vernonia Seed

Vernonia seed oil and trivernolin obtained by commercial extraction of imported and domestic Vernonia seed under our supervision was refined and more than thirty industrial requests for samples were fulfilled. Several large manufacturers of plasticizers evaluated these products and reported favorably on their use in poly(vinyl chloride) (PVC) formulations. One report stated "both materials proved to be very interesting as stabilizing plasticizers for

PVC, particularly the trivernolin oil. Trivernolin compares favorably with epoxidized soybean oil for all permanence properties and light stability and shows slight improvement over Peroxidol 780 for long-term heat stability. Both trivernolin and the Vernonia seed oil have low temperature properties which would be comparable to an epoxidized tallate ester such as Peroxidol 781."

Over three hundred samples of seeds from the 1964 crop, grown in collaboration with the New Crops Research Branch, CRD, ARS, were analyzed (bringing the total number to about 800 samples covering a nationwide area) for quality as judged by oil content and oxirane oxygen and free fatty acid content of the seed oil. Analytical methods were scaled down ten to one in order to analyze and save seed for individual plants selected through cooperation with Purdue University investigators who are performing breeding experiments to obtain high quality, early maturing seed.

A series of aliphatic esters of vernolic acid was prepared for evaluation as primary plasticizers for PVC. Preliminary results have indicated that these esters have potential use as low temperature plasticizers.

A study of the composition of the unsaponifiable fraction which amounts to six to eight percent of the composition of Vernonia anthelmintica seed oil has been started. Infrared spectra and chemical tests indicate that the unsaponifiables contain a number of individual sterols that collectively account for about fifty-eight percent of this fraction. Two hydrocarbon portions representing about four to five percent of the unsaponifiables were isolated by column chromatography. The larger of the two portions was a saturated hydrocarbon with a chain length of about C 20.

Preliminary work was done with the oilseed, Euphorbia lagascae. This seed contains about fifty percent oil rich in cis-12,13-epoxy-cis-9-octadecanoic (vernolic) acid (sixty to seventy percent). The vernolic acid seems to have a random or restricted random distribution in the glycerides of this species. Prepressing experiments indicate that a prime high quality light-colored oil can be obtained in a good yield from this seed and additional good quality oil can then be extracted from the pressed seed cake. The enzyme systems of Euphorbia lagascae are not as active as those present in Vernonia anthelmintica seed and do not have the unique characteristics of the latter.

Summary of Five Years' Research On Epoxy-bearing New Crop Seed Oils.

Since this work on new crop seed oils was discontinued at the Eastern Division, it seems appropriate to give a brief resume of the overall progress made at the Eastern Division from May 19, 1960, to May 19, 1965.

Four major components, trivernolin, 1,3-divernolin, vernolic acid and 12,13-dihydroxyoleic acid and an unsaponifiable fraction were isolated and prepared in quantity from this seed oil. Foreign and domestic Vernonia seed varied in oil content within wide limits, (10% to 32%; good quality seeds provided 25%

to 30%, with 70% to 75% trivernolin content); the relative amounts of components present in the oil depended upon the manner in which the seed was handled in processing. Minor components found in the seed oil as glycerides were linoleic acid, about 9%; oleic acid, about 2%; palmitic, about 3%; stearic, about 1%; and other fatty acids in trace amounts.

Optimum conditions were worked out for processing Vernonia seed to trivernolin-rich oil and directly to trivernolin, chief component in the oil. These conditions were tested on a larger scale at EU, in a commercial pilot plant and in a small soybean extraction plant under EU investigators' supervision. Vernonia seed was processed in the soybean plant without modification of existing equipment and without lipolysis.

Industrial testing and evaluation studies performed at EU confirm the value of Vernonia products as plasticizer-stabilizers in poly(vinyl chloride) formulations. The Vernonia seed oil and trivernolin compared favorably with epoxidized soybean oil and the metal salts of vernolic acid were superior as heat and light stabilizers of PVC to those presently in use.

The enzyme systems present in Vernonia seed were found to be unique; inhibition and acceleration techniques for their control were developed. A lipolytic principle specific for the hydration of the number two position of glycerides appeared to be present. An enzymatic method for conversion of vernolic acid to 12,13-dihydroxyoleic acid was discovered.

With respect to refining and improving the quality of Vernonia products, (1) poor quality domestic Vernonia seed was upgraded by a process of air-flotation which separated a light fraction (immature seed high in dihydroxyoleic acid) from a heavy fraction (high in the desired epoxyoleic acid); (2) Vernonia oil was refined to high quality for evaluation studies by a combination of adsorbents and removal of unsaponifiables (about 10%) at low temperatures; (3) highly purified (about 100%) trivernolin, divernolin and vernolic acid were prepared by a combination of procedures, crystallization, treatment with adsorbents, solvent partition and column chromatography.

Stability tests were completed on Vernonia seed, the seed oil and on trivernolin. Storage of whole seed for periods up to three years did not affect the quality of the seed oil but the ability of the enzyme systems to act when the seed was crushed appeared to increase with time. The epoxy content of low free fatty acid content Vernonia oil and trivernolin changed only slightly when these products were stored at room temperature for six months. However, the viscosity of the samples that were exposed to light increased greatly, indicating changes in the physical nature of these products.

Nutritive value studies on Vernonia seed meal in cooperation with the Pharmacology Laboratory, WU, have demonstrated that in rat feeding Vernonia seed pericarp and kernel when autoclaved will produce good growth rates at twenty percent dietary levels compared with rates of control animals. Pancreatic enlargement and growth inhibition were observed in rats fed unautoclaved kernel fraction from Vernonia meal. The nature of this undesirable factor which was destroyed by heat is not known. When fed to rats Vernonia seed oil and trivernolin were purgatives.

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NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods and on how to conserve or enhance these values in household and institutional preparation and processing. Periodic surveys of the kinds, amounts, and costs of foods consumed by different population groups and individuals also are essential to evaluate the nutritional adequacy of diets and to give the guidance needed for effective programs of nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas is 77.5 man-years. It is estimated that 2.4 man-years is concerned with studies related to oilseeds and peanuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 30.2 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to fats and oils, and peanuts are considered briefly in this report.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient value of foods. Research on the nutritive composition of food is often concentrated on locally produced commodities. With the increase of processed and prepared foods, much of the evaluation is related not only to genetic factors and feeding practices but to changes induced by processing and storage to arrive at a value which represents the dietary contribution of the product.

The chemical structure of fats and lipids in food stuffs and the changes involved in processing, holding, and final preparation are receiving special attention as the problem of fats in human nutrition continues an active area of research and speculation. Protein and amino acid content and alteration with heat processing remain active research areas. The importance of conjugates of protein and lipids especially as they are formed in food processing, is being investigated in relation to their nutritive characteristics. Research has been directed toward the vitamin content of food as related to inherent inhibitory and stimulatory factors.

The total program in this area includes 38 projects in 24 States and is comprised of approximately 27.3 professional man-years.

Properties related to quality and consumer use of food. Research on food preparation for consumer use may be accompanied by measures of quality from the raw state, through handling and processing for marketing, to final home and institutional service. Special measures characterize certain classes of products; e.g., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues.

The structure of baked products as related to the physical and chemical properties of the starches used and supplementary products involved as fats and sugars are the subjects of ongoing basic research in the carbohydrate area. The physical structure of frozen and stored batters and doughs is under study.

Special research emphasis is on the physical and chemical alterations involved in home preparation of foods. This work is carried out with the objective of having foods of maximum quality and nutritional value for final consumption. These researches include the effect of the use of saturated and unsaturated fats and oils on the quality of the final product baked at variable altitudes, and flavor characterization in frozen and stored products by means of vapor component identification. Many of these same factors are being investigated for institutional preparation where the quantities involved impose special conditions.

The State program in this area includes 55 projects in 27 States and involves approximately 50.5 professional man-years. This is a partial report of the State Experiment Station program in food science and includes the work undertaken and participated in by Departments of Home Economics. For research on food and fiber, see the reports of the Utilization Research and Development Divisions, and Clothing and Housing Research Division.

Food consumption and diet appraisal. The State program in food consumption and diet appraisal extends the work of the Department to selected segments of the population or to smaller geographic areas. One continuing investigation in the North Central Region is planned to yield information regarding food purchase and consumption patterns of families with preschool children. This research will provide information of use to both consumer education and market interests. A continuing consumer panel in a Southern metropolitan area is providing information on purchase patterns, including data on changes in form, amount, kind, expenditure, and nutritive value of foods purchased. Attempt is made to identify and quantify in a relative sense the factors effecting change.

Currently 16 States are contributing to the Experiment Station program in this area which totals 22.7 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Quality and Use of Oilseed and Peanut Flours

Research on quality and use of food products in which a major part of the protein is derived from cottonseed, peanuts, and soybeans was initiated in cooperation with the Agency for International Development and the Northern and Southern Utilization Research and Development Divisions. Basic formulas and preparation procedures are being developed for use by families and community groups in various underdeveloped countries of the world where these plant proteins are available but not used to any extent in the human diet. The flours have been used in beverages for babies, cookies, leavened and unleavened breads, stews, and other food formulations. Experimental flours prepared by new processes have been evaluated for their solubility, thickening power or viscosity, particle size, and palatability in beverages and performance in baked products.

B. Nutritional Evaluation of Fats and Oils

1. Heated and oxidized fats. The effect of oxidation upon the nutritive value of different dietary fats has been followed in long-term studies conducted under research contracts with Columbia University, New York City, and with Swift and Company, Chicago, Illinois. Mild oxidation of cottonseed oil, olive oil, beef fats, or chicken fat had little influence on the lipid composition of the tissues when fed to rats. These fats were oxidized at 140° F. by aeration for a period of 40 hours. Continuing studies will provide information for butter and lard. The results also suggested that the body is able to rearrange the constituent fatty acids as supplied by the dietary fat and,

despite similarity in total fatty acid composition, each organ appears to fashion its own triglycerides. A paper reporting these findings was presented at the meeting of the American Oil Chemists and is being prepared for publication.

Other studies evaluated the influence of more severe oxidation produced by heating hydrogenated cottonseed oil, vegetable oil, corn oil, and lard without aeration for 120 hours at 360° F. These conditions are somewhat more drastic than would be encountered with the mild treatment that fats usually receive in the home or under the conditions of commercial use, but are still comparable to some food preparation practices. The results obtained with the fats investigated to date indicate that any changes due to heat treatment were without harmful effects as determined by the physiological response to diets containing these fats. Animals fed the heated fats ate more than those fed unheated fats, with the greatest differences being observed in the intake of those fed lard or cottonseed oil. When fed heated or unheated hydrogenated vegetable oil, the animals lived somewhat longer than those fed cottonseed oil, corn oil, or lard. These results were reported at a meeting of the Federation of American Societies for Experimental Biology and a paper will be prepared for publication.

2. Dietary fat and insecticides. Research is being initiated that should aid in establishing whether the presence of the chlorinated hydrocarbons in food could influence metabolic response during growth and reproductive stress and periods of dietary restriction. Under contract with Swift and Company, Chicago, Illinois, investigations will be conducted to determine the effect of feeding diets containing selected types of heated and unheated fats, with and without added chlorinated hydrocarbon pesticides, on growth and reproductive performance of the rat through three generations. The heated fats will be prepared under conditions similar to those used for a previous study (B-1 above). Selected tissues will be analyzed for pesticide residues to determine the extent to which these pesticides may accumulate in the tissues without harmful effects. The pesticides may be added in amounts that will not exceed currently accepted tolerance levels and will be in the proportions found in composite diets recently analyzed by Food and Drug Administration.

3. Dietary fat and serum proteins. Fatty acids are known to complex with certain protein components in blood as a means of lipid transport. Research to determine the possible effect of the kind and level of dietary fat on the relative proportion of various serum protein components has been carried out in order to obtain basic information on the response to dietary fat and to aid in our understanding of the role of the blood proteins in the transport of fat. Fats used in the study included corn oil, safflower oil, hydrogenated vegetable oil, lard, and butter. Serum proteins were analyzed electrophoretically using moving boundary electrophoresis. Both age of animal and kind of dietary fat were found to influence the concentration of certain of the protein components in the blood of rats. A component moving more rapidly than albumin and containing both fat and protein, was found to be particularly susceptible to the kind and level of fat in the diet as well as to age of the

animal. Differences due to kind of fat were not related to any specific characteristic of the fat. The functions of these fat-protein complexes remain to be elucidated.

4. PL 480 studies of diet and fat metabolism. Many factors are known to affect fat metabolism. Among these are genetics, age, and other physiological and environmental including numerous dietary factors. In one PL 480 project in India, the effect of diet on hormone regulation of body synthesis and mobilization of fat is being studied with laboratory rats. One group of animals is receiving a fat-free laboratory diet, and others are receiving protein and fat combinations characteristic of three population diets in North, South, and Central India. For comparison other rats are maintained on regular stock ration.

In normal animals, the North India combination of 20 percent animal protein (casein) plus 20 percent butterfat caused significant rise in serum cholesterol; the South India combination of legumes (vegetable protein about 10 percent) and 10 percent coconut oil caused high initial serum cholesterol which in 30 days fell to levels below those on the stock ration; and the South India combination of another vegetable protein and 10 percent sesame oil gave the lowest serum lipid levels of all. Rats on fat-free diets of 18 percent casein and 64 percent cornstarch and 12 percent sugar had serum cholesterol significantly above animals on the stock ration or on any of the population type of diets. Maximum synthesis of body fat occurred also on the fat-free diet. Irrespective of the diet used, removal of the thyroid gland led to higher serum cholesterol but it was most exaggerated on the North India combination. Administration of thyroid hormone tended to reverse the effect on all diets. Removal of adrenal glands depressed lipid metabolism but the effect was only partially corrected by corticosteriods, one hormone produced by the adrenals.

C. Nutritional Evaluation of Food Proteins

Statistical analyses of nitrogen-balance data for 24 young women fed diets containing the FAO pattern of essential amino acids and the patterns in nonfat milk solids, whole egg, oatmeal, and peanut butter were interpreted as indicating (a) that young women, when fed amino acids as in the FAO pattern, required a minimum of .22 gm tryptophan and other essential amino acids as in this pattern to maintain nitrogen balance, (b) that the nutritional value of a protein depends in part upon factors other than the amount of the limiting amino acid, and (c) that one possible factor may have been the larger amount of nitrogen from essential amino acids in the food patterns than in the FAO pattern. The data were obtained in contract research with the University of California at Los Angeles, Oklahoma State University at Stillwater, and the University of Wisconsin at Madison. A manuscript presenting an evaluation of the combined data has been accepted for publication in the American Journal of Clinical Nutrition.

At the Agricultural and Technical College of North Carolina at Greensboro, a study was initiated to investigate the response of 13 young men to a diet providing 46 gm protein per day and in which wheat provides 75% of the protein. This diet is being compared to three similar diets in which 20% of the wheat protein is replaced by protein from each of peanut butter, rice, and pinto beans. Data are to be obtained on nitrogen and mineral balance, intake and output of selected vitamins, and on the serum levels of amino acids, total cholesterol, phospholipids, glycerides, and total lipids.

D. Tables of Food Composition

1. B-vitamins and trace elements in foods. Compilation of data is well underway for the following B-vitamins--pantothenic acid, vitamin B_6 and vitamin B_{12}, and has been initiated for several trace elements. Data for these nutrients were not in the 1963 revision of Agriculture Handbook No. 8 "Composition of Foods...Raw, Processed, Prepared." Special attention is being given to compiling data on cobalt, copper, manganese, molybdenum, selenium, and zinc.

2. Nutritive values of retail and household units of food. A table is being developed that will give nutritive values for many of the foods in Handbook No. 8 in terms of market units of the items as usually purchased and in terms of household measures of prepared foods. The data needed to prepare this supplement to the 1963 edition of the Handbook are being obtained through consultation with representatives of industry and of Consumer and Marketing Service as well as through observation of products offered for sale.

3. Special services. Research findings compiled from the world's literature on the nutritive value of foods continue to be in constant demand as background material for dealing with a wide variety of problems. Technical assistance was given in the formulation of a statement on nitrogen conversion factors for the Protein Committee of the Food and Agriculture Organization of the United Nations, in the development of policy and guidance for the Food for Peace Program, and in the development of educational materials on the so-called convenience foods for the use of dietitians in teaching diabetics. Information on the composition of specific foods or groups of foods was also given to research teams conducting dietary surveys, to welfare workers and to agencies of the Federal Government such as the Federal Trade Commission, the Food and Drug Administration, and the National Institutes of Health. Within USDA, information was provided for revising several of the tables in Statistical Bulletin No. 362, Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products, issued in June 1965.

E. Food Consumption and Diet Appraisal

1. 1965 nationwide survey. A nationwide survey designed to provide information on the food consumption and dietary levels of people in the United States is now underway. Data on the kinds and quantities of food used during one week were collected under contract from more than 7,500 representative

U.S. households between April 7 and July 3. Similar data will be obtained from 2,500 households each in the summer and fall of 1965 and the winter of 1966. Information on the food eaten both at home and away from home during one day was provided by 13,000 individuals who were members of the families providing information on household food consumption during the spring of 1965. The study was designed to provide data for the four Census regions for farm, rural nonfarm, and urban populations for the year as a whole and for the four seasons.

Detailed tabulation plans have been drawn up that will provide for a series of volumes on the household data obtained in the spring of 1965 similar to those published for the 1955 survey. Other tabulation plans will provide information on (1) the 12-month period April 1965-March 1966 and for the four seasons, (2) the relationship between the money value of household food and its dietary adequacy, and (3) the intake of both food and nutrients of individuals by age and sex.

2. Effects of food distribution programs on diets of needy families. Analyses of data from studies in Detroit, Michigan, and Fayette County, Pennsylvania, conducted to obtain information on the effectiveness of the Food Donation and Food Stamp Programs showed the following. (1) Many of the families participating in the Food Donation Program failed to participate in the Food Stamp Program when it replaced the Donation Program. The families who did participate in the Food Stamp Program were usually those of younger homemakers with more formal education, more young children, and lower incomes for family size. (2) Calcium and ascorbic acid were the nutrients which increased most when the Food Stamp Program replaced the Food Donation Program. They were also the nutrients in which diets were most limited (according to the National Research Council allowances) under both the Food Stamp Program and the Food Donation Program. (3) The overall quality of diets was better under the Food Stamp Program than under the Food Donation Program. (4) Under the Food Stamp Program participants received coupons which would purchase food worth considerably more in money than the foods received under the Food Donation Program--approximately 135 percent more in Detroit and 65 percent more in rural Fayette County. They were also able to make their own selections.

A study of families participating in the Food Donation Program in Baltimore showed that little or no dietary improvement occurred when the number of donated foods was increased from five to eight. Families cut back on their food purchases, apparently using the funds thus made available for other needs.

3. Food consumption of the rural population in Spain (PL 480 Research). A 1964 survey of the food consumption of the rural population in Spain, conducted by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using PL 480 funds, showed the percentage of income spent for food was much higher than in the U.S. However, the nutritive content of the diet was considerably

lower than that of rural families of the U.S. For example, the average amount of calcium in the diet was about 0.5 g. per person per day compared to 1.2 g. in the diets of rural families in the U.S. in 1955. The percentage of calories from fat was 31 percent compared to 41 percent in the diets of rural families in the U.S. Although a wide variety of foods was used, a large share of the diet was supplied by bread, potatoes, dried beans, milk, olive oil, and wine. Tabulation of data from a second survey conducted in the early months of 1965 is in progress.

4. Nutritive value of national food supply. The revision of estimates of the food energy, protein, fat, carbohydrate, calcium, phosphorus, iron, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid content of the per capita food supply from 1909 to the present has been completed. The revised figures incorporate newest estimates of per capita food consumption developed by the Economic Research Service, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

The revised estimates and tables showing the contribution of major food groups to the total supply of each nutrient for selected years were published as Chapter 5 of Statistical Bulletin No. 364, "U.S. Food Consumption--Sources of Data and Trends," Economic Research Service, June 1965.

The estimates for nutrients together with the per capita food quantities on which they are based are extremely useful in studying dietary trends.

5. Support for food and nutrition programs. The compiling and interpreting of research-based information on nutrition for application to problems of food selection and food use is continuing. The information so developed serves as a basis for assistance to many groups both within and outside the Department. For example, technical advice and guidance were given during the year to the School Lunch Division, Consumer and Marketing Service, in revision of two publications designed to help improve the nutritional quality of school lunches. Also assistance was given to the Office Economic Opportunity in the preparation of "Nutrition Guidelines" for the Project Head Start Centers Feeding Program.

Publication of Nutrition Program News and participation in the Interagency Committee on Nutrition Education, for which CFE furnishes the secretariat, are continuing as a means of coordinating and strengthening nutrition programs in general. A noteworthy accomplishment was the development by the Committee of four basic nutrition concepts to be used as guidelines for program planning and curricular development in nutrition education.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Friend, B., and Albright, T. M. 1965. Nutritive value of food available for consumption. Chapter 5 in U.S. Food Consumption--Sources of Data and Trends, 1909-63. Statistical Bul. No. 364.

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Peterkin, B., and Evans, B. 1965. Food purchasing guide for group feeding. Agriculture Handbook No. 284.

Peterkin, B. 1964. Family food plans, 1964. Family Economics Review. Oct., pp. 11-21, and Separate.

Support for Food and Nutrition Programs

Hill, M. M. 1964-65. Nutrition Program News. (Periodical, 5 issues).

Mickelsen, O. 1964. Nutrition science and you. Vistas of Science, No. 10, National Science Teachers Association in cooperation with ARS, USDA. July.

Phipard, E. F., and Kirby, R. H. (ERS). 1964. Nutritional status of the world, Chapter in Farmer's World, 1964 Yearbook of Agriculture.

III. MARKETING AND ECONOMIC RESEARCH

OILSEEDS AND PEANUTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete revaluation of handling and storage methods for farmers' stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artifical drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers' stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State College.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves $81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Aspergillus flavus Link and its infectivity to plants and harmfulness to animals. The project (line project A10-CR-46) runs from 1963 to 1968 and involves $129,250 equivalent in Israeli pounds.

The Federal scientific effort devoted to research in this program totals 5.0 professional man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, the Field Crops and Animal Products Research Branch, growers' cooperative associations, and various industry groups.

The Federal scientific effort devoted to research on prevention of insect infestation was 2 professional man-years during the reporting period. In addition, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored peanuts.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

A considerable amount of the genetic, breeding, variety, and cultural research on oilseeds and peanuts has the ultimate objective of increased market quality. Other studies are generally directed to determining the influence of variety, stage of maturity, and harvesting and handling practices on the market quality of the oilseed crop.

In the case of peanuts, the breeding objectives relate to yield, disease, and insect resistance, local adaptation and trueness to market types. Studies more directly related to quality are concerned with the effects of fungi on market value of the seeds and the fermentation products produced by fungi growing on peanut substrates. Market quality studies relate to effects of mechanical harvesting and curing, temperature-time-moisture relationships on keeping quality and on the market value of peanuts as affected by changes in storage. The quality of processed peanut products is being studied and the relationship of maturity and curing practice to finished product quality is being determined.

Research which relates to the history and control of insects affecting peanuts, soybeans, and other oilseeds is reported in Area 13. Factors which affect soybean quality are involved in such breeding program objectives as improved resistance to disease, high oil content, and seed

quality. Illinois is evaluating the quality of soybeans and soybean products for human consumption. Missouri is studying genetic and environmental factors which affect the market value and quality of soybean seed for planting. Other research is directed to solving problems associated with storage and handling of oilseeds. For example, developments in the mechanization of castor bean production and handling are being investigated. Along with development on production, State stations study the effects of conditioning and storage upon market value.

Total market quality research effort on peanuts and oilseeds at the State stations is approximately 6.7 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. A cleaner for separating samples of farmers' stock peanuts into foreign material, loose shelled kernels and whole peanuts has been developed. The machine reduces the time required for an inspector to separate a sample of peanuts from approximately 10 minutes to less than 3 minutes. About 75 machines are being purchased by private industry for use by the Inspection Service in the Southeastern peanut area during 1965. The machine will be tested in the Virginia-Carolina area and in the Southwest during the 1965 marketing season.

A simple device has been developed to prevent peanuts from wedging in the opening between the inner and outer tubes on the pneumatic sampler. The device eliminates the necessity to periodically clean the peanuts from between the two tubes and should speed up the sampling operation. The device was developed and tested in cooperation with the Federal-State Inspection Service in Georgia.

A special seal for the roller adjustments on the peanut presizer has been developed and the presizer will be used as the official method for determining the percent fancy size in Virginia-type peanuts. Use of the presizer for this purpose will eliminate hand-screening of peanuts which is time consuming and highly subjective.

(MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Acetaldehyde, ethyl acetate, and ethanol, thought to be the main components of high-temperature off-flavor in peanuts but present in trace amounts in the 1963 normal-flavored peanuts, were not present in normal flavored peanuts from the 1964 crop.

The complete absence of these compounds is of particular importance since the occurrence of these compounds might be used on an index of high-temperature off-flavor. An active alcohol dehydrogenase system from peanut kernels has been isolated and shown to be active in crude preparations from peanut seeds.

A survey was made using gas chromatographic methods on runner and Spanish peanut samples which had been evaluated organoleptically to have an off-flavor or good-flavor by commerical standards. Qualitative and quantitative differences were observed between these peanuts from both runner and Spanish types. These findings, along with those from high-temperature cured Virginia type peanuts indicate that gas chromatography can be used as a useful quality evaluation tool on peanuts.

(MQ 3-26c)

3. Natural Antioxidants in Vegetable Oil Storage. Preliminary analysis of the data, prior to statistical interpretation, indicate that gossypol antioxidants are depleted rather rapidly in storage even at the lower temperatures, whereas, tocopherols require longer periods and higher temperatures for depletion. Also, increase in primary oxidation products occur comparatively rapidly when storage temperatures are above 90°F, with formation of secondary products earlier than previously expected.

(MQ 3-25)

4. Soybeans. A growing problem, particularly in the Southern States, involves the damage done by stinkbugs to soybeans. Preliminary chemical tests on lots of damaged and undamaged soybeans indicate that oil content is decreased and fat acidity increased as a result of the damage. A research contract has been let with the University of Arkansas for controlled experiments on this problem. The effort to find a chemical method for detecting stinkbug damage is continuing.

(MQ 3-65)

5. Distinguishing Soybean Particles from Foreign Matter. Samples of soybean particles and foreign material that pass through an 8/64th-inch grading screen were collected from grading offices throughout the United States. There were no marked differences in the composition of screenings from the various locations. Each area had the same types of weed seed and other foreign material in about the same proportions, about 79% foreign material and 21% soybean particles. Separation of the screenings through use of an electrostatic charge was not successful. The most successful method for separating the screenings employs the use of air flow to separate the light, chaffy material, and an inclined, vibrating surface to partially separate the weed seeds and soybean particles. By this method, one man can

separate 12 grams of screenings in about 10 minutes. Preliminary tests with knurled steel rollers indicate that soybean particles become imbedded in the knurls more readily than weed seeds. Tests on this method of separation for soybean particles and weed seeds have not been completed.

(MQ 3-24)

B. Quality maintenance in storage

1. Flaxseed Storage. Results indicate that in spite of molds, enzymes, and bacterial activity on seed in high-temperature high-humidity storage, the oil after refining, was of as good quality as oils from seed processed before storage. Seed stored at lower humidity had a similar increase in peroxide value as that of high humidity stored seed.

(E21-AMS-6)

2. Soybean Oil Storage. The most precise measure of determining decrease in quality was found to be the decrease of color of the refined oils and the decrease in refined color of the crude oils. Increase in peroxide value was directly related to decrease in refined color, and can be predicted based on the initial refined color and the refined color during storage. Moisture and volatile matter, regardless of initial content, approached a constant value, depending on location of storage. Most refined soybean oils increased in free fatty acids and most crude oils increased in refining loss during storage, depending on initial content, but rarely exceeded specifications of the National Soybean Processors Association.

Flavor panel scores of several of the stored refined oils after deodorization and aging at 60°C for 4 days were significantly related to storage peroxide value and to dimer content. Relationships between stored peroxide value and dimer conent of the deodorized refined oils were highly significant both with free access and limited access to air during storage. Two marketing research reports are in process of publication based on data obtained from a 4-year study of stored once-refined, crude, and degummed crude soybean oils.

(MQ 2-44)

3. Development and Control of Mycotoxins in Spanish Peanuts. The concentration of aflatoxins in farmers' stock Spanish peanuts was related to pod perforation. Damaged kernels from pods with growth cracks contained aflatoxins in concentrations 2000 ppb; apparently undamaged kernels from such pods contained from 500 to 1000 ppb. No aflatoxins were detected in either damaged or undamaged kernels of Spanish peanuts from 3 locations assayed immediately after digging.

Aflatoxin concentrations were high and Aspergillus flavus-oryzae spp were the most prevalent fungi in peanuts stored experimentally at moisture contents of 23 to 34 percent. The development of A. flavus species and aflatoxins is regulated in part by competition with other fungi. The ability of other fungus species of the peanut mycroflora to metabolize aflatoxins was demonstrated.

Non-sterile farmers' stock and shelled Spanish peanuts were inoculated with dry spores of a known high-aflatoxin-producing strain of A. flavus and stored at 30°C in relative humidities ranging from 75 to 100% for periods up to 4 weeks. The toxin concentration in the shelled peanuts exceeded 400 ppb after one week in storage at 85% relative humidity but decreased to 36 ppb after 4 weeks. The toxin concentration increased to a maximum of more than 500,000 ppb after 4 weeks at 100% relative humidity. With farmers' stock peanuts, toxin concentrations exceeding 50 ppb were not detected until the peanuts had been stored for 4 weeks at 93% minimum relative humidity; at that time the toxin concentration was greater than 2,000 ppb.

(MQ 2-103)

4. Molds and Aflatoxin. Tests with peanuts inoculated with a toxic producing strain of Aspergillus flavus have shown: (a) the peanut hull helped prevent the production of aflatoxin in peanut kernels by mold; loose shelled kernels and kernels from broken hulls contained much higher levels of aflatoxin than kernels from sound hulls, (b) curing treatments presently recommended for Virginia-type peanuts prevented the production of aflatoxin if the peanuts were not badly damaged by toxic molds before the start of drying, (c) prolonged periods in the windrow at high moisture contents did not cause aflatoxin production in cool weather (average low of 60°F and average maximum of 70°F), (d) inverting the windrow so that the peanuts were exposed to the sun caused the peanuts to dry more rapidly and reduced the risk of mold growth and aflatoxin production, and (e) moisture contents between 15 and 30 percent were more conducive to aflatoxin production than higher or lower moisture contents, requiring about 50 hours at 90°F and 100 hours at 70°F. The major concentration of aflatoxin was in damaged peanut kernels with no significant difference between visible or concealed damage. Elimination of damaged and shriveled kernels significantly reduced the concentration of aflatoxin in contaminated lots of peanuts but there was no general correlation between damage and aflatoxin levels in farmers' stock peanuts.

(MQ 2-107)

5. Vegetable Oil Storage. Olive, peanut, and soybean oils were stored at 30, 40, and 55°C for one year. With increasing temperatures, the peroxide values increased and the increase was more rapid in the refined than in the crude oils. There was a tendency for the aldehyde values to increase, but no significant change in iodine value, acidity, or thiobarbituric acid. The pro-oxidant effect of metals, partially and totally immersed in the oils at

room temperatures, generally decreased as follows: copper, iron, zinc, tin, and stainless steel. The oils in partially filled bottles increased in peroxide value faster than oils in totally filled bottles when various colored screens were used. The catalytic effect of light was less than higher temperatures in the dark. There was no outstanding improvement in maintaining low peroxide value with any of the several colored screens tried.

(E15-AMS-12)

C. Prevention of insect infestation

1. Nonpesticidal Control Methods. Stainless steel towers (2.18 cu. ft.) containing shelled or farmers stock peanuts were purged with nitrogen or carbon dioxide at flow rates of 50, 100, and 200 ml./min. for 7 consecutive days. Adult red flour beetles were exposed in the towers at depths of 10, 22, 34, and 46 inches below the surface of the peanuts for 2, 4, and 7 days. Both carbon dioxide and nitrogen provided effective control (80- to 100-percent mortality) of the insects within 2 days when the gas was allowed to flow into the towers at 200 ml./min. At flow rates of 50 and 100 ml./min., carbon dioxide usually produced greater insect mortality than did nitrogen, even though the latter was more effective in purging the oxygen from the towers containing peanuts. There was greater insect mortality at the 46-inch depth in the peanuts than at the 10-inch depth, with the gases being introduced from the top of the towers.

Effective control (80- to 100-percent mortality) of red flour beetle adults and larvae, and of Indian-meal moth larvae was obtained in 14 days at 60°F and 64 percent relative humidity in a nitrogen-purged atmosphere when the oxygen concentration was reduced to about 1 percent, and in 7 days in a carbon dioxide-purged atmosphere when the oxygen concentration was reduced to about 7 percent and the carbon dioxide concentration increased to about 65 percent.

Two diatomaceous earths, Kenite and Perma-Guard, and 2 silica aerogels, Drie-Die SG-68 and Cab-O-Sil M-5, each at 3 different treatment levels on farmers' stock peanuts are included in intermediate-scale tests now in progress. Observations after the first 6 months of the test show that 10.5 lbs./ton and the two silica aerogels at 1.5 lbs./ton are as effective as the standard malathion treatment. Kenite-treated peanuts had the lowest percentage of insect-damaged kernels during the first 6 months of storage. Perma-Guard and the lower application rates of the other dusts were not as effective as malathion.

(MQ 1-27 (Rev.))

2. Improved Pesticidal Control. Diazinon at 5, 10, and 20 p.p.m. was equal to or better than the standard application of 52 p.p.m. of malathion in intermediate-scale tests of protective treatments on farmers' stock peanuts. The peanuts treated with 5 and 10 p.p.m. of diazinon contained

less than 1 p.p.m. after 6 months; those treated at 20 p.p.m. contained 3.4 p.p.m. Fenthion at 20 p.p.m. was nearly as effective as the malathion standard. Dichlorvos was highly effective for the first 3 months of the test, but protection was of short duration. Peanuts treated with 20 p.p.m. of dichlorvos contained only 1 p.p.m. after 1 month.

(MQ 1-27 (Rev.))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Schroeder, H. W. and L. J. Ashworth, Jr. 1965. Aflatoxins in Spanish Peanuts in Relation to Pod and Kernel Condition. Phytopathology 55:464-465.

(MQ 2-103)

Ashworth, L. J., Jr., H. W. Schroeder, and B. C. Langley. 1965. Aflatoxins: Environmental Factors Governing Occurrence in Spanish Peanuts. Science 148:1228-1229.

(MQ 2-103)

MARKETING FACILITIES, EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Differences in varieties of individual field crops and in the environments of producing areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to the efficient and economical handling, conditioning, and storing of these crops and to maintaining their quality. There is a need for improved designs for facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department has a long-term program involving engineers engaged in both applied and basic research on, as well as application of known principles to, the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, storing, and shelling of peanuts is conducted by the Albany, Georgia, field office at laboratory and pilot-scale facilities in Dawson and Bainbridge, Georgia, in cooperation with the Georgia Agricultural Experiment Stations, the Market Quality Research Division, and with various industry firms.

The Federal effort devoted to research in this area during the fiscal year 1965 totals 4.0 professional man-years to the handling, drying, aerating, storing, and shelling of peanuts.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Shelling, Handling, Drying, Aerating, and Storing Peanuts

1. Shelling. A total of 130 tons of Spanish-, Runner-, and Virginia-type peanuts were shelled in the experimental shelling plant at Dawson, Ga., during the 1964-65 shelling season. Peanuts were obtained for the tests from the Southwest, Southeast, and Virginia-Carolina producing areas.

Three different types of shellers--grate, bar, and basket--were tested. Sheller speeds of 165, 200, and 235 r.p.m. and various grate openings and sheller-bar spacings were used in the tests. Test results indicate little difference in shelling damage (splitting) between the three types of shellers at the speeds tested. Motion pictures of peanuts being shelled failed to reveal the sheller action that causes pods to break open.

Cleaning.--Tests were run with model cleaners to determine better methods of removing foreign material from farmer stock peanuts. A revolving, cylindrical shaped basket did not remove an acceptable amount of foreign material during one pass through the stick removing mechanism. All methods tested failed to remove an acceptable amount of foreign material without also removing an excessive amount of peanuts.

Presizing.--Two model presizers were built each using a different principle of separating farmers stock peanuts according to pod size. Limited testing indicated that there is as much variation in pod size within a type of peanuts as there are between types of peanuts. Additional tests are planned during the 1965 season to determine size groups within types of peanuts.

2. Handling. Continuing tests with conventional bucket elevators indicate that buckets at a 12-inch spacing can handle more farmers stock peanuts than those at a 6-inch spacing. These results are contrary to engineering data on bucket elevators showing that buckets at a 6-inch spacing handle more dense materials at a faster rate.

3. Drying. A total of 81 drying tests (27 for each of the three types of peanuts) were run in the experimental pilot-scale drying unit at Bainbridge, Ga., during the 1964 harvest season. Three drying treatments were tested; two with peanuts exposed to heated air for continuous periods of one hour, and the third for periods of one-half hour. Drying air temperatures as high as 145° F. were used.

Samples of peanuts from each drying test were analyzed to determine the effects of each treatment on peanut taste, splitting, skin slippage, and the build up of aflatoxin. Results indicate that air temperatures as high as 145° F. are practical for drying Runner- and Virginia-type peanuts with the limited exposure methods. It also appears that the time peanuts are in the drying unit can be substantially reduced. Spanish-type peanuts appeared less tolerant to the higher drying air temperatures. Out-turn of shelled goods from the experimentally-dried peanuts showed less milling damage than from peanuts dried at commercial dryers. Assays for aflatoxin indicated a reduction in contamination with the higher drying air temperatures.

Additional research is planned for the 1965 harvest season. Tests will be made with a new experimental belt-type dryer designed by TFRD personnel, with a pilot-scale batch dryer, and with an infrared radiation dryer.

4. Aeration. Continuing studies on aerating stored farmers stock peanuts at Bainbridge and Columbus, Ga., indicate that maintaining the desired kernel moisture content of 7 to 8 percent is practical with aeration. Limited tests indicate that the build up of undesirable free fatty acids in aerated peanuts is less than in non-aerated peanuts and that a darker skin color is more pronounced in non-aerated peanuts.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

None.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Economic research in agricultural marketing revolves around the problems of increasing efficiency in the processing and distribution system and providing a foundation for orderly adjustments to changes inside and outside of agriculture. Marketing must be looked upon as a dynamic and changing process. The capacity to adjust to and cope with the dynamics of modern marketing is required increasingly of producers and distributors of farm products. Demands of a more knowledgeable and sophisticated consuming public are adding to the pressures for an even more rapid escalation of developments and changes within the marketing system. Changes in insitutions and redirection of public policies and programs are modifying the economic environment in which marketing firms must perform and operate. Because of rapid changes and increasing complexities associated with a dynamic marketing system, it is necessary that a continuous program of research be conducted in marketing--a program aimed at keeping producers and marketing firms abreast of the flow of events and providing information necessary to them in making proper and orderly adjustments to change.

Of increasing economic concern is the problem of how to improve and strengthen markets for farm products in face of a continuing rise in production, higher distribution costs, and competition from nonagricultural products. The problem of increasing demand for farm products to meet rising productivity has become progressively more pronounced in the last decade. Interest in the development of markets has mounted as larger and larger financial outlays become necessary for price-support operation and maintenance of reasonable levels of farm income.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program of economic research directed in two major areas: (1) Organization and performance of markets and (2) development of markets. Research on organization and performance is designed to increase the efficiency of marketing and assist producers and marketing agencies in adapting to a changing environment. Research is conducted on a wide range of functional and commodity problems that arise in moving farm products from producers to consumers. The program involves both basic and applied research and is primarily oriented to problems of national and regional scope. Field studies are often conducted jointly with State agricultural experiment stations, with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented trade groups. Producer groups and trade organizations have, with increasing frequency, made financial contributions to the Division research efforts. Many staff members are working closely with the staff of the

National Commission on Food Marketing in a consultative role and in research studies on price spreads and market structure. These studies are partly financed by the Commission. Of this research effort, approximately three professional man-years were devoted to oilseeds and peanuts.

Research on development of markets consists of both basic and applied research on agricultural commodities which includes the development of general principles in advertising and promotion, appraisal of public food distribution programs, and evaluation of the commercial feasibility and market potential for new and improved products. Of this research effort approximately two professional man-years were devoted to oilseeds and peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

Fifteen studies in 13 States are concerned with the direction and magnitude of major changes in firm organization, economic forces, policies, and practices influencing changes in marketing grain and the relationship between economic forces and policies and the trends in market structure. Information on consolidation, integration, mergers, and their consequences, along with decision-making processes, is being sought. Information on the magnitude and future course of changes would help in expediting and directing feasible trends.

Many of the State experiment stations analyze the supply, demand, and price situation for the products of their State. USDA research is often used as a base but further research usually is needed to meet State and local needs.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Prices, Margins, and Costs

In the last decade, prices to consumers for most products of farm origin have risen despite downward trends in farm prices. This widening of farm-retail spreads has brought widespread public concern about the efficiency and performance of the marketing system which culminated in the establishment of a National Commission on Food Marketing.

Much of the rise in retail prices of fiber, grain, and oilseed products can be attributed to increased costs of processing and distribution. Research is needed to determine the magnitude of these changes and to find means of processing and distributing these products more economically.

By establishing the prices shellers pay for the various kernel grades of farmers' stock peanuts, the peanut price support program can influence sheller decisions as to the quality of farmers' stock peanuts to market through commercial trade channels. A mathematical programming simulation model of the peanut shelling industry has been developed to estimate the

total quantities and qualities of farmers' stock peanuts that would be demanded by the commercial shelling industry under various assumed farmers' stock price relationships. The model is being applied to Virginia-type peanuts and coefficients for the Spanish and Runner peanut analyses are being developed.

B. Products and Services

Continuing emphasis is being placed on oilseeds, particularly the soybean in view of the successful work accomplished on the project relating to the use of whole soybeans for feed in making mixed feeds. Information was developed for farmers, livestock and poultry feeders, and feed mill operators so as to allow them to make a decision as to whether or not processing of soybeans in this way was economically feasible under local conditions. Work is being initiated on the market for safflower oil and meal. This research will tie in closely with the physical research program on safflower oil carried on at the Western Laboratory.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Products and Services

Doty, Harry O., April 1965. Cooked Soybeans for Feed. ERS-228, 8 pp.

COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers continue to increase their use of cooperative marketing. These cooperative operations are conducted in a marketplace where handling and processing, transportation, and distribution technology is changing rapidly, and market organization and practices are undergoing major changes. Farms themselves have changed. Farmers and their cooperatives need research results that relate to these developments and new conditions to assist them in marketing efficiently. Such research will assist farmers to strengthen their bargaining power, increase marketing efficiency, and meet effectively the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a direct and major way for farmers to get maximum returns from their products. Farmers own and operate cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan and actually conduct the specific marketing program and services that will yield best returns for their members. Marketing cooperatives must know what the consumer demands, as reflected in the market. They must be able to estimate the cost of serving the market in different ways. They must understand the possibility of major economies in a well-managed joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through appropriate organization, good use of existing plant and personnel, and the correct selection and use of new equipment and methods.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 19.6. Of this number, 2.2 were devoted to oilseeds, peanuts, and sugar.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. This report includes work conducted during the present period, or release of results of

work earlier completed, through contract research performed by universities in Iowa, Montana, North Dakota, and West Virginia, and by two private research companies.

STATE EXPERIMENT STATION PROGRAM

Most of the commodity marketing research of the agricultural experiment stations is helpful to marketing cooperatives. Some projects, however, deal specifically with cooperative marketing problems, opportunities, and impacts. At the present time 10 States have 12 research projects in cooperative marketing. Their commodity distribution is as follows: grain-2, tobacco-1, fruit and vegetables-1, livestock-2, and cross-commodity-6.

Some projects evaluate the performance and organizational features of cooperatives. Different methods of pooling and their problems are studied so as to develop helpful principles. In the analysis of cooperative operations and in working with directors and managers, efforts are made to identify and solve the many problems that are arising. Particular attention is given to what services or functions should be provided by cooperatives. There is interest in learning more about the attitude of members and nonmembers toward cooperative marketing, especially the differences in these attitudes.

In the last few years more attention is being given to the role of cooperatives in achieving bargaining power for farmers. In connection with market structure studies, special attention is being given to the impact of cooperatives on market conduct and performance.

The total research effort on cooperative marketing in the 10 States is 2.5 professional man years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Improving operating and handling methods

Research was underway in several commodity fields to examine new methods, equipment, and structures for efficient and safe processing and storage of agricultural products by cooperatives.

Oilseeds. The cost of electric power at cottonseed oil mills under different electric rate schedules was analyzed. Different rate schedules result in widely different total cost, it was shown. Managers may use these findings to obtain more equitable power rates in some cases.

Analysis of operating costs of cooperative cottonseed and soybean processors continued. Findings help operators to locate inefficient features of their operations and on the basis of this information, act to reduce costs, and thereby increase returns to growers. Based on the work and experience with

these processors, we continue to handle requests from interested groups on the feasibility of constructing and operating soybean processing plants. These reports also are used by other agencies in the Department of Agriculture and by the banks for cooperatives serving these mills.

B. Improving the organization, financing, and management of marketing cooperatives

Oilseeds. A general study was initiated of the organization and operations of cottonseed and soybean oil processing and marketing cooperatives.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Biggs, G. W. 1964. Marketing Farmers' Stock Peanuts in the Virginia-North Carolina Area. Proceedings of the Third National Peanut Conference, Auburn University, Auburn, Alabama.

ing, R. A., Biggs, G. W., Jones, E. W., and Miller, B. R. 1965. Peanut Handling: Economic Implications of the Shift from Bag to Bulk in the Virginia-North Carolina Area. Marketing Research Report No. 711.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA AND COOPERATIVE PROGRAM

Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation and occasionally in monthly issues of the Farm Index and the Agricultural Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals are given at meetings with industry groups. Special analyses are prepared on the probable effect of proposed programs on the acreage, price, supply, and demand for oilseed crops and for fats and oils and their products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, 1909-63, is being revised and updated for publication.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Fats and Oils

Increased attention was given to soybeans during the year under review. Soybeans now rank third among cash crops in the United States behind corn and cotton. Also, record dollar exports of soybeans and soybean oil and meal in fiscal 1965 carried the oilseed and product commodity group to its fourth consecutive year as top dollar earner among U.S. agricultural exports.

Coverage of the fats and oils situation was broadened by an article, published in the November 1964 Fats and Oils Situation, on the soybean processing industry. This article provided data on the number of mills operating and estimated processing capacity, total and that utilized, 1951-64. It revealed that processing capacity exceeds actual crushings by about 20 percent despite the sharp upward trend in soybean production and the steady reduction in number of mills. Trends toward larger but fewer mills, the integration of soybean crushings with feed-mixing and other sideline activities, and excess processing capacity all will tend to keep continued pressure on processing margins.

An article in March 1965 analyzed the trends in U.S. soybean acreage and production, by regions, 1947-65. During the post-war period, over 20 million acres had been shifted from other crops (mainly oats, corn, and cotton) to soybeans. The most challenging problem facing researchers and the industry was how to raise soybean yields per acre from the plateau on which they had remained for the past 8 years.

A special article in August 1965 explained the implications of shifting the U.S. soybean marketing year to a September 1-August 31 basis. The marketing year formerly started October 1. The primary reason for the shift has been the trend toward earlier soybean harvest with an increasing amount of the crop harvested in September. The article marked the official USDA shift in the soybean marketing year.

An article on postwar trends in U.S. peanut acreage, production, and usage in May 1965 was the most comprehensive of its kind in over a decade and incorporated new statistical series published for the first time. The analyses included changes in the peanut price support program, shifts in the production and yields in the 3 major peanut-producing areas, shelling outturns, quality factors by type of peanut, and trends in peanut consumption.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Fats and Oils

Kromer, George W. Fats and Oils Situation. Published 5 times a year. ERS, USDA, Washington, D.C.

Kromer, George W. November 1964. U.S. Soybean Processing Capacity Continues to Expand. Fats and Oils Situation, pp. 48-50.

Kromer, George W. January 1965. Recent Trends in U.S. Production and Consumption of Edible Meat Fats. Fats and Oils Situation, pp. 29-35.

Doty, Harry S. March 1965. Cooked Soybeans for Feed. Fats and Oils Situation, pp. 36-42.

Kromer, George W. March 1965. Trends in U.S. Soybean Acreage and Production, 1947-65. Fats and Oils Situation, pp. 27-35.

Kromer, George W. May 1965. Trends in U.S. Peanut Acreage, Production and Usage, 1947-65. Fats and Oils Situation, pp. 21-37.

Campbell, Proctor. August 1965. U.S. Soybean Oil Export Markets. Fats and Oils Situation, pp. 37-40.